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PROCEEDINGS

of the

American Gas Institute

FIFTH ANNUAL MEETING

OCTOBER 19, 20, 21, 1910

NEW YORK, N. Y.

PUBLISHED BY THE INSTITUTE

EDITED BY THE PUBLICATION COMMITTEE

1911

PRESS OF
THE CHEMICAL PUBLISHING COMPANY
EASTON, PENNA., U. S. A.

A512p
1910

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of the

AMERICAN GAS INSTITUTE

1909 - 1910

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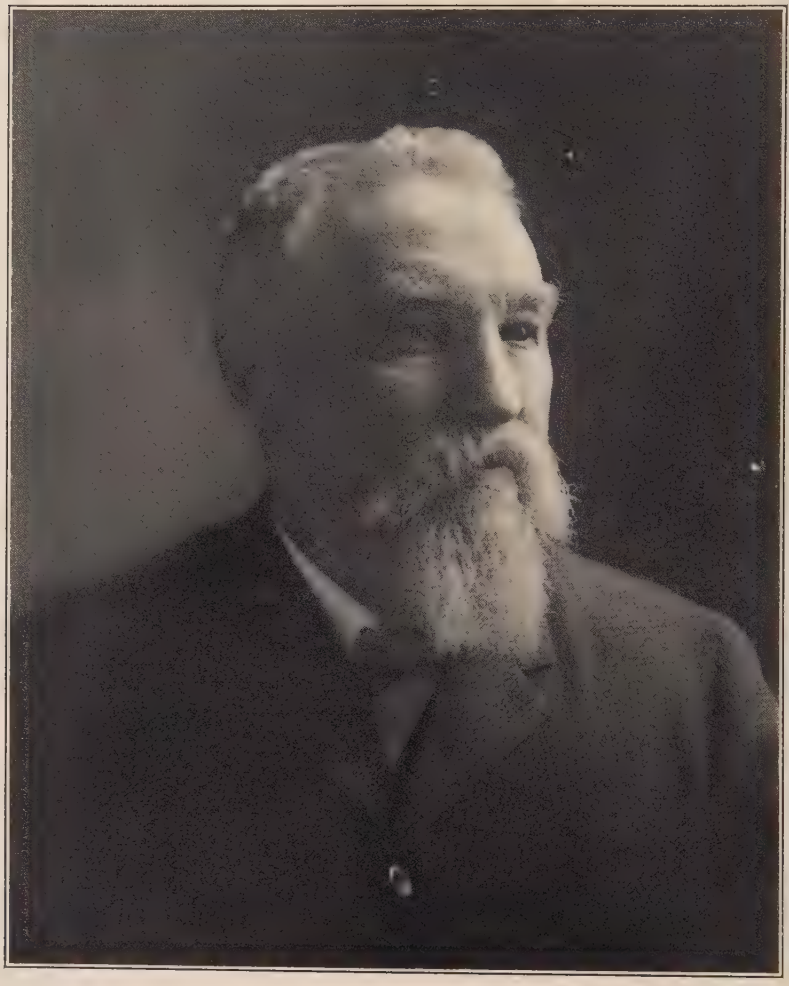


F. H. Bradley

Report of the Proceedings

of the

American Gas Institute

Fifth Annual Meeting

held at

New York City

October 19th to 21st, inclusive, 1910.

The Fifth Annual Meeting of the American Gas Institute, held in the Engineering Societies Building, New York City, was called to order by the President, Mr. William H. Bradley, at 10:15 A. M., Wednesday, October 19, 1910. There were 540 members registered as attending this meeting.

Minutes of Previous Meeting.

The President: Gentlemen, I would suggest, as the minutes of the last annual meeting have been printed and distributed to all the members, that we dispense with the reading and save time.

A motion was made, seconded and carried that the reading of the minutes be dispensed with.

Welcoming New Members.

The President: Gentlemen, we have with us to-day many new members. There have been eighty-seven elected during the last year. On behalf of the Institute, I extend a hearty welcome to all the new members and trust that they will be instructed and benefited by the meeting. As the list of new members elected has been printed and distributed, it is useless to take up time by reading it.

Report of Directors.

The President called for the report of the Directors, and the Secretary read the same, as follows:—

Report of Directors.

October 19, 1910.

To the American Gas Institute,

Gentlemen:

The Board of Directors has the honor to submit its Fifth Annual Report, as follows:

Meetings.

Three meetings of the Board have been held during the year. The regular summer meeting, August 10th; a special meeting, to elect a nominating committee, September 30th; a regular meeting October 18th.

Committee of Arrangements.

In accordance with By-Law 22, the following Committee on Arrangements for the Fifth Annual Meeting was appointed. W. R. Addicks, Chairman; T. N. McCarter, A. C. Humphreys, Jas. H. Jourdan, L. B. Gawtry, C. M. Higgins, George G. Ramsdell, Alfred E. Forstall, H. L. Doherty, W. W. Randolph, W. Cullen Morris, W. Greeley Hoyt, George E. Woods, R. W. Bush, W. J. Clark, E. H. Rosenquest, Carleton Macy, G. H. Woodall, William J. Welsh, C. G. M. Thomas, Thos. C. Byrne, C. S. Fox, A. H. Hall, Secretary and Treasurer.

Abstracts.

The publication of the Bulletin of Abstracts has been continued. The thanks of the Institute are due to the United Gas Improvement Company for furnishing the material for these abstracts.

Membership Committee Report.

The list of new members elected during the year is as follows:

Election of March 5, 1910.

Active Membership.

Alden, John Douglas, Assistant Superintendent, United Gas Improvement Company, Waterbury, Conn.

Anson, Charles Lyman, Superintendent of Manufacture, Northwestern Gas Light & Coke Company, Oak Park, Illinois.

Burkhardt, H. W., Superintendent Gas Department, South California Edison Company, Los Angeles, California.

Clark, Horace Herbert, Superintendent of Mains and Services, Northwestern Gas Light & Coke Company, Oak Park, Illinois.

Deal, Erastus Charles, Manager, North Carolina Public Service Company, Greensboro, North Carolina.

DeFreitas, William, Assistant Superintendent Consolidated Gas Company, New York City, General Fuel Appliance Dept.

Douglas, David, President and General Manager, Eau Claire Gas Light Company, Eau Claire, Wisconsin.

Down, Frederick J., Superintendent, 42d St. Station, Consolidated Gas Company, New York City.

Eaton, Homer M., General Manager, Flint Gas Co., Flint, Michigan.

Fancher, Nathaniel C., Superintendent Lake Station, Seattle Lighting Company, Seattle, Washington.

Fielis, Edward B., Secretary of New York and Richmond Gas Company, Staten Island, N. Y.

Frueauff, Harry D., Treasurer and General Manager, Pueblo Gas & Fuel Company, Pueblo, Colorado.

Hillemeyer, Jos. E., Engineer, Suburban Electric & Power Co., St. Louis, Mo.

Howland, Lewis A., General Superintendent, Queens Borough Gas & Electric Company, Far Rockaway, New York.

Huestis, Leon David, Superintendent Operation, Coke Oven Department, Suburban Gas Company, Chester, Pa.

Jackson, Thomas H., Assistant General Agent, Philadelphia Gas Works, The United Gas Improvement Company, Broad and Arch Sts., Philadelphia, Pa.

Kahn, Samuel, General Manager, Union Light, Heat & Power Company, Fargo, North Dakota.

Kendall, Albert Whittemore, Assistant Manager, Rockford Gas Light & Coke Company, Rockford, Illinois.

Knapp, William Jared, Assistant Superintendent, Division St. Station, Peoples Gas Light & Coke Company, Chicago, Illinois.

North, Edwin, Purchasing Agent, Consolidated Gas Company, 4 Irving Place, New York City.

Pearsall, Edward L., General Manager, Gas & Electric Co., Bloomington, Ill.

Peters, Henry, Superintendent, North Station, Peoples Gas Light & Coke Company, Chicago, Illinois.

Priest, George Heywood, Gas Engineer, with Stone & Webster Engineering Corporation, 147 Milk St., Boston, Mass.

Riblet, Albert, Superintendent 14th St. Station, Consolidated Gas Company, New York City.

Robinson, William Thomas, Secretary and Treasurer, American Gas Company, Philadelphia, Pa.

Simpson, Colin C., Jr., Assistant Engineer, Department Mains & Services, Consolidated Gas Company, New York City.

Stack, Edward M., General Superintendent, Hyde Park Gas Company, Scranton, Pa.

Stiles, Linford Spearing, Construction Engineer, The Brooklyn Union Gas Company, Brooklyn, N. Y.

Whitney, Roy Foxwell, General Manager & Treasurer, Peoples Gas & Electric Company, Oswego, N. Y.

Wiley, Lynan A., Secretary, Peoples Gas Light & Coke Company, Chicago, Illinois.

Associate Membership.

Bestor, Frank C, Manager Tar Products Department, Kettle River Quarries Company, Minneapolis, Minn.

Bowman, William George, Salesman, Schneider & Trenkamp Company Division, Chicago, Illinois.

Hyde, Dr. Edward P., Director, Physical Laboratory, National Electric Lamp Association, Cleveland, Ohio.

Mingus James B., Sales Agent, Penn Gas Coal Company, Philadelphia, Pa.

Potter, Clifford C., Manufacturer's Agent for Detroit Graphite Company, New York City.

Rust, Robert Ripley, Superintendent of Foundries, Central Foundry Company, New York City.

Junior Membership.

Crankshaw, J. Ward, District Sales Manager, Kensington Branch, United Gas Improvement Company, Philadelphia, Pa.

Mueller, Adolph F., Head Bookkeeper, Seattle Lighting Company, Seattle, Washington.

Raabe, Charles, Cadet Engineer, Westchester, Lighting Company, Mt. Vernon, N. Y.

Severson, Robert Kilburn, Chief Clerk, City District Philadelphia Gas Works, United Gas Improvement Company, Philadelphia, Pa.

Warner, Charles Pierie, Cadet Engineer, Syracuse Lighting Company, Syracuse, N. Y.

Transfers to Active Membership.

Callenbach, J. Anton, Chemist, Merchantville, New Jersey.

Crane, William M., President, New Bern Gas Company, New Bern, North Carolina. New York City.

Eavenson, William K., Gas Engineer, with General Fuel Appliance Department, Consolidated Gas Company, New York City.

Offutt, M. Webb, General Manager, Mohawk Gas Company, Schenectady, N. Y.

Owens, Harry Thurston, Consulting Engineer, New York City.

Petura, Frank Joseph, Gas Engineer, care of H. L. Doherty & Co., 60 Wall St., New York City.

Terhune, Charles F., Vice-President, New Bern Gas Co., New Bern, North Carolina. New York City.

Election of September 20, 1910.

Honorary Membership.

Dr. Charles F. Chandler, New York.
Corbet Woodall, London, England.
William King, Liverpool, England.

Active Membership.

Anderson, Edgar Voorhees, Superintendent of Construction, Poughkeepsie Light, Heat & Power Co., Poughkeepsie, N. Y.

Ashworth, James, Superintendent of Distribution, Public Service Gas Co., Jersey City, N. J.

Barlow, Thaddeus Scott, Assistant Superintendent, Consolidated Gas Co., New York City.

Bell, Clement H., Manager & Superintendent, Yankton Light & Heating Co., Yankton, S. D.

Brown, Samuel W., Superintendent, Columbia Gas Light Co., Columbia, S. C.

Byrne, Edward Louis, Superintendent Fulton Works, The Brooklyn Union Gas Co., Brooklyn, N. Y.

Dewey, Maurice J., Foreman, Gas Plant, San Antonio Gas & Electric Co., San Antonio, Texas.

Doane, George W., President, New Amsterdam Gas Co., New York City.

Franzini, Joseph Bernard, Superintendent Gas Distribution Dept., San Antonio Gas & Electric Co., San Antonio, Texas.

Freeman, Frederick Charles, Engineer in Construction Department, The United Gas Improvement Co., Philadelphia, Pa.

French, Chas. S., Secretary & Treasurer, Galveston Gas Co., Galveston, Texas.

Gardner, Lester Durand, General Manager, Blaugas Co. of America, New York City.

Gefvert, Chas. J., Engineer's Asst., Consolidated Gas Co., New York City.

Hewitt, Arthur, General Manager, Consumers Gas Co., Toronto, Ont., Canada.

Hirst, Jr., Homer T., Assistant Superintendent, North Division, Peoples Gas Light & Coke Co., Chicago, Ill.

Hirst, Jesse Bowman, Superintendent of Pressures, Peoples Gas Light & Coke Co., Chicago, Ill.

Houghton, Charles P., Third Vice-President, Los Angeles Gas & Electric Corporation, Los Angeles, Cal.

Hunter, Chas. Wesley, President & General Manager, Citizens Gas Co., Ocala, Fla.

Jacobson, Ernest, Assistant Superintendent, Division St. Station, Peoples Gas Light & Coke Co., Chicago, Ill.

Marrow, George Peek, Engineer, with Bartlett, Hayward Co., New York City.

Rafferty, James Aloysius, Assistant Superintendent, Peoples Gas Light & Coke Co., Chicago, Ill.

Reinhard, Solon A., Assistant Superintendent, South Station, Peoples Gas Light & Coke Co., Chicago, Ill.

Scofield, Thomas, Illuminating Engineer, Consolidated Gas Co., New York City.

Tripp, George B., General Manager, The Colorado Springs Light, Heat & Power Co., Colorado Springs, Colo.

Vance, Champ Shepherd, Manager of Operation, Los Angeles Gas & Electric Corporation, Los Angeles, Cal.

Van Den Driessche, Achilles, Assistant Engineer, Consolidated Gas Co., New York City.

Waterbury, Herbert Jessup, Manager, Marquette Gas Light Co., Marquette, Mich.

Weber, F. C., Superintendent, Freeport Gas Light & Coke Co., Freeport, Ill.

Werner, Louis H., Secretary, Central Union Gas Co., Bronx, New York City.

Associate Membership.

Dougherty, Charles, Air Compressor and Pneumatic Tool Salesman, Ingersoll-Rand Co., Brooklyn, N. Y.

Foster, F. H., Salesman, Detroit Stove Works, Peoria, Ill.

Hornsey, John W., Chief Engineer, General Reduction Gas & By-Products Co., New York City.

Parker, John F., Western Sales Manager, Eclipse Gas Stove Co., Rockford, Ill.

Plucker, Howard W., Salesman, with J. A. Sheppard & Co., Philadelphia, Pa.

Salt, Thomas, Superintendent, Coke Oven Department, Illinois Steel Co., Joliet, Ill.

Youngman, Robt. H., Asst. to President, Harbison-Walker Refractories Co., Pittsburgh, Pa.

Junior Membership.

Bird, Viggo F., Employed in Engineering Work, Fall River Gas Works Co., Fall River, Mass.

Henson, Edward B., Assistant Foreman, Gas Plant, San Antonio Gas & Electric Co., San Antonio, Texas.

Kelley, Jr., Timothy Jeremiah, Foreman of Fitting Shop, Beloit Water, Gas & Electric Co., Beloit, Wis.

Reyburn, John Randolph, Engineer, The Paducah Light & Power Co., Paducah, Ky.

Sherwood, Herbert, Chief Clerk, Westchester Lighting Co., Mount Vernon, N. Y.

Smith, Jr., George Perry, Superintendent, Missoula Gas Co., Missoula, Mont.

Tozer, Henry, Foreman Street Mains, Westchester Lighting Co., White Plains, N. Y.

Transfers to Active Membership.

Boyd, Albert Mathew, Superintendent of Germantown District, Philadelphia Gas Works, Philadelphia, Pa.

Hinman, Charles W., Chemical Engineer, Lowell Gas Light Co., Lowell, Mass.

Keppelman, D. Elwood, Superintendent, Meter Department, San Francisco Gas & Electric Co., San Francisco, Calif.

Pickens, Arthur Guy, Engineer, South Bend & Mishawaka Gas Co., South Bend, Indiana.

Stevick, Crist H., Assistant Superintendent, Ravenswood Works, New Amsterdam Gas Co., Long Island City, N. Y.

During the year the resignations of 12 members were accepted, and 11 members have died. At the end of the fiscal year, September 1, 1910, 48 members were, by vote of the directors, dropped from the list for non-payment of dues.

Total members at beginning of year		1332
Elected during year		87
		1419
Resigned	12	
Died	11	
Dropped	48	
	71	71
Present Membership		1348

Approximately 60 applications for membership have been received too late for the fall election.

Secretary's Report on Badges and Proceedings.

Badges.

On hand September 1, 1909		60
Purchased during year		50
To account for		110
Sold during year	50	
On hand September 1, 1910	60	
		110

Proceedings.

Proceedings Vols. 1, 2 and 3.	
In stock Sept. 1, 1909	781
Sold during year	36
In stock September 1, 1910	745

Proceedings Vol. 4.		
Received from printer		1650
Sent to members	1372	
Sent to exchanges	59	
Sold	21	
	1452	1452
In stock September 1, 1910		198

REPORT OF THE TREASURER.

October 18, 1910.

To the Board of Directors, American Gas Institute,

GENTLEMEN:—I have the honor to present herewith the Report of the Treasurer, for the Fiscal Year ending August 31, 1910.

Receipts.

Back bills	$ 560.00
Current Dues (1910)	10,900.00
Initiation Fees	1,295.00
Bulletin of Abstracts	1,610.85
Badges Sold	187.60
Proceedings Sold	354.00
Miscellaneous Sales	108.83
Interest on Bank Balances	133.88
Total receipts	$15,150.16

Expenditures.

Publishing Bulletin of Abstracts	$ 1,299.80
Rent offices and storeroom	1,636.85
Printing and Stationery	216.48
Reporting Meetings	386.85
Premium on Surety Bond	40.00
Premium on Fire Insurance	11.20
Binding Journals and Books	40.40

Publishing and Shipping Proceedings	2,975.95
Subscription to Educational Fund	350.00
Express on Proceedings, etc., sold	89.80
Postage	239.48
Exchange on Checks	5.80
Expenses Detroit Meeting	308.39
Printing Advance Papers	892.48
Typewriter and Bookcases	182.25
Badges for Stock	175.00
Miscellaneous Expense	173.52
Salary, Secretary-Treasurer	3,000.00
Stenographer and Clerical Assistance	875.00
Total Expenditures	$12,899.25

Summary for the Fiscal Year.

Total receipts	$15,150.16
Total Expenditures	12,899.25
Balance	2,250.91
Balance on hand Sept. 1, 1909	2,065.38
To account for	$ 4,316.29
Balance in Columbia Trust Company, as per bank statement, August 31, 1910	4,494.00
Less outstanding check No. 363	250.00
	$ 4,244.00
Checks and cash in hands of Treasurer, Sept. 1, 1910	72.29
	$ 4,316.29

Amounts Outstanding.

Delinquent Dues for one year (1910)	$ 1,140.00
Delinquent Dues for two years (1909-10)	1,370.00
Delinquent for Abstracts one year (1910)	135.00
Delinquent for Abstracts two years (1909-10)..	55.00
Delinquent Miscellaneous Sales	31.25
	$ 2,731.25

Liabilities.

None, except for Current Bills.

Respectfully Submitted,

A. B. BEADLE, Treasurer.

REPORT OF FINANCE COMMITTEE.

October 18, 1910.

To the Board of Directors, American Gas Institute,

GENTLEMEN:—Enclosed please find report of the Treasurer for the fiscal year ending August 31, 1910. Your Finance Committee has audited the books, accounts and statements of the treasurer, and finds the report to be correct.

Respectfully submitted,

J. D. SHATTUCK, Chairman.
J. B. KLUMPP,
H. L. RICE.

SUPPLEMENT TO TREASURER'S REPORT.

Cash Statement from Sept. 1, 1910, to Oct. 15, 1910, inclusive.

Received from dues, etc.	7,144.08
Balance September 1, 1910	4,316.29
	11,460.37
Expenditures to Oct. 15th, inc.	2,654.02
Balance October 15, 1910	$8,806.35

Report of Trustees Gas Educational Fund.

The annual report of the Trustees Gas Educational Fund will be presented at this meeting, to the Institute as one of the subscribers to the fund.

The Board recommends that the Institute continues its annual subscription of $350 for this fund.

Reports of Committees.

The reports of the Public Relations and Technical Committees have been approved by the Directors, and will be submitted to the members in the course of the meeting.

The reports of the following sub-committees of the Technical Committee have been approved for reading at this meeting.

Bureau of Information. V. F. Dewey, Chairman.

Wrinkle Department. R. C. Congdon, Editor.

Progress Department. W. E. McKay, Editor.

Committee on Calorimetry. J. B. Klump, Chairman.

Committee on Thermal Value and Candle-Power. A. C. Humphreys, Chairman.

Committee on Consumers Meters. Chas. C. Schiller, Chairman.

Papers to be Read at this Meeting.

The Board has approved 18 papers to be read at this Meeting, as follows:

"Manufacture of Balloon Gas in Water Gas Apparatus," George H. Waring.

"Waste Heat Utilization in Water Gas Apparatus," J. Hawley Taussig.

"The Extraction of Cyanogen from Coal Gas at Astoria Works," M. E. Mueller.

"Determination of the Calorific Value and of Operating Conditions from Analysis of Industrial Gases," J. M. Morehead.

"The Public Deceived by Faulty Data and Misleading Analysis of Data," Dr. A. C. Humphreys.

"Continuous Carbonization in Vertical Retorts," J. S. De Hart, Jr.

"The Lighting and Ventilation of Gas Appliance Display Rooms," T. Scofield.

"Laying One 48-inch and Two 36-inch Gas Mains Under the Harlem River," C. C. Simpson.

"The Laying of a Pair of 36-inch Cast Iron Mains Under the Passaic River Opposite the City of Newark, N. J.," A. H. Strecker.

"A Review of Recent Decisions of Public Service Commissions which affect Gas Companies," A. E. Forstall.

"Cultivation of Friendly Relations Between the Public and the Lighting Company," W. J. Clark.

"Apparatus Designed for Remote Control of District Pressure," J. S. Kennedy.

"Pumps for Gas Works Purposes," H. L. Underhill.

"Brick, Concrete and Steel Holder Tanks," H. W. Alrich.

"Construction of a Reinforced Concrete Tank for a Gas Holder," V. L. Elbert.

"Pneumatic Caulking with Lead Wool of 30-inch, 36-inch and 48-inch Mains," C. C. Simpson, Jr.

"Accuracy of Consumers' Meters," W. A. Castor.

"Removal of Organic Sulphur from Gas," H. M. Papst.

Delegate to the International Photometric Commission.

During the year the President appointed Dr. E. P. Hyde as a delegate to represent the Institute at the proposed meeting of the International Photometric Commission. This meeting was postponed until next year.

The Board recommends that action be taken as to a delegate for next year's meeting.

All which is respectfully submitted for the Board of Directors.

W. H. Bradley, President.
A. B. Beadle, Secretary.

THE PRESIDENT: Gentlemen, you have heard the report of the Directors. What is your pleasure?

A motion was made, seconded and carried that the report be accepted and placed on file.

THE PRESIDENT: In the report there are one or two recommendations to be acted upon. The first is that the subscription of three hundred and fifty dollars to the Trustees of the Gas Educational Fund be continued.

A motion was made, seconded and carried that the same be continued.

THE PRESIDENT: There is also a recommendation that a delegate to the International Photometric Commission be appointed by the President.

A motion to that effect was made, seconded and carried.

THE PRESIDENT: The next order of business, gentlemen, is the Presidential address.

The President then called Mr. John C. D. Clark, Second Vice-President, to the Chair.

The President then read his address as follows:—

PRESIDENT'S ADDRESS.

It is with great pleasure at the opening of this Fifth Annual Meeting of the American Gas Institute, that I extend to you all a most hearty welcome to the Empire City of the Empire State. It is especially pleasing to note the full attendance, and that we have with us so many members who have journeyed far from distant cities to take part in, and assist in the work of our organization. The usual Presidential address that is expected on these occasions will be necessarily brief, as the Technical Committee have prepared a programme of unusual length and variety that will require all the time at our disposal to complete. I shall, therefore, only touch upon such matters as appear to be important at this time as concerning the Institute and its work, and one or two subjects of general interest to our members, and not attempt to discuss matters of published record so readily available to all in the columns of the technical journals. It has been sug-

gested that I discuss the present policy of the Institute, and outline a future policy. It is not within the province of the individual, except through the medium of the Directors, to indicate or say what shall be the future policy of the Institute, but, it may not be amiss to consider for a few moments the general situation, after four years of life of the Institute, and see if we can gain any information, or if any conclusions can be drawn that have a bearing on present conditions as they may seem to exist; and, if improvement is desirable or possible in the tone or work of the Institute, how such improvement can be made. It is evident that one thought in the minds of those who proposed, advocated and finally accomplished the amalgamation or consolidation of the American, the Western, and Ohio Associations into the present American Gas Institute, was that "In Union there is Strength," and that one organization under favorable conditions and loyally supported by all its members could, and would do better and more efficient work than could be expected from many small organizations, each working independently of the other; and again, as many of us were members of several, more or less, of these smaller bodies whose meetings were held at different times and in different localities, that much time would be saved by attending one annual meeting as against several; and also, that the amount of money required to be expended by the members for annual dues and travelling expenses would be reduced to the minimum,—the logical deduction being, that few, if indeed any more, similar organizations would be formed. That this was correct in theory is beyond dispute, but it does not seem to have fully worked out in practice. Many new State and District Associations have since been formed and others are contemplated, so that there are now many more than at the time of the formation of the Institute. In addition to these, are also the Illuminating Engineering Society and the National Commercial Gas Association, both comparatively new organizations. It is an undeniable fact that the work of these two latter societies runs in parallel lines to the work of the Institute. This was recognized last year

in Detroit, and a resolution was passed at that meeting, having for its purpose some form of amalgamation with the latter organization. This became impossible at this time, because of the decision of the National Commercial Association, that it would not be to its advantage to make any arrangement of the kind at present. It is, however, possible and even probable that the question may be brought up again during the coming year. Having in mind this entire situation, the subject of Company Membership was brought up at a meeting of the Directory held in this city in the summer of 1910, when it was discussed both formally and informally, with the result that the President was directed to appoint a committee to consider and formulate a scheme of Company Membership to be reported back to the Directors, who would decide whether in their judgment they should recommend its adoption by the Institute. This action was taken too late to enable the committee to report, except, perhaps, to report progress at this session, and while not attempting to anticipate the report, it will probably provide, in substance, that the membership of the Institute is to be composed, partially at least, of delegates from, and appointed by the Gas Companies; that the formation of State or District Societies is to be encouraged, and that periodically, reports or bulletins of such of the proceedings of these societies as are of general interest, are to be forwarded through a committee of the Institute to each individual member of these several organizations.

This mere outline is given that you may have the subject in mind and give some thought to it in advance of a possible decision of the Directors that such a change is desirable, and that the question possesses sufficient merit or importance to warrant its presentation to the Institute for action.

The success of the Institute, as now constituted, depends not alone on the efficiency and work of its Officers and Committees, but also largely on the cordial support and assistance given them by the individual membership. If we believe that we fill the measure of our responsibility to ourselves, to the companies we represent, or to the Institute, by simply paying

our annual dues, attending the annual meetings, and return to our respective homes, giving no further thought to the Institute and its work until the occurrence of the next annual meeting, then there is grave danger that the control of the Institute and its affairs will pass into the hands of the few, or working members, instead of remaining in the hands of the many, as it should for the benefit of all concerned.

The papers that are to be presented at this meeting I have alluded to as being many and varied in character; but, I may also say that there is but one that can be called a voluntary contribution; and further, that the great majority of them are from members connected with the larger companies. This fact has been freely commented upon before, and should be corrected. We have young men, managers and engineers of the smaller installations, who have both the ability and opportunity to prepare papers that would prove both valuable and instructive, and it is eminently desirable for the benefit of the Institute and the entire membership, that they should come to the front and take active part in this work and also in the management of the Institute. They should not hesitate, because of a feeling of youth and inexperience—quite as much, and perhaps more consideration will be shown them by the Institute, because of this fact. The older and more experienced members, are fully aware that they are not yet the custodians of all the knowledge to be obtained in the gas industry, and are all willing to gain more knowledge, even from the young members. It is neither necessary nor desirable that all papers should be severely technical—popular papers —if I may so term them, relating to methods of operation or construction; records and results of experiments carried on with a definite purpose; notes on new, or changes made in old distribution systems; on the uses of gas; and papers on business methods, are but a few of the topics that would be always welcome with the technical papers. Even records of failures are valuable, (I assume there are but few of us who have not, at times, made failures) and while it is all important that we should know what to do, it is equally important

to know what not to do. Again, the managers or engineers of the smaller installations are able to observe and attend to matters of detail, so desirable in preparing papers, to an extent that is not possible with the managers or engineers of the larger installations, who must, of necessity, delegate much of the detail work to others.

A word as to the educational annex of the Institute. Few of us, except we have been brought into intimate contact with it, have any conception of the amount of time and labor that is given, freely and without stint, by the Trustees in carrying on this work. We should endeavor to assist and encourage them in every way possible, perhaps, by suggesting to the financial officers of our several companies that are not already subscribing, that a subscription to the fund would be acceptable and useful; by looking over the gas makers and others employed in our plant, selecting those likely to become interested in the subject of a better education, suggesting the matter to them, and if occasion presents itself, assisting them to solve the problems given out in the various classes, and reap our reward in the consciousness that we have done something to forward the Institute work, and, at the same time, increase the self-respect, the efficiency and value to our company and to ourselves of some of our coworkers. It is not to be inferred from the preceding remarks, that it is in the mind of any of us, that the Institute is not at present doing good work, or that it is retrograding in its work or influence, as the contrary is the case. It is progressing, but not, perhaps, to the extent that is desirable or possible; and I have been prompted to make these observations, solely, with the sincere wish and hope, that the result may be the awakening of more of our members to a fuller appreciation of their duties and privileges in the Institute; and, in this way, to at least partially dispel the atmosphere of seeming indifference, and initiate an era of progress and interest that will result in placing the American Gas Institute where it rightfully belongs; in the front rank among the technical societies of the world.

One important question, perhaps, the most important in its influence upon the entire industry, is the proposed change of the standard of value as applied to the manufacture and use of artificial gas. The adoption of a calorific or thermal standard of value to take the place of the present photometric or candle-power standard. A calorific standard has already been adopted in some states, and is being seriously considered in the State of New York as well as in others. It has also been adopted, to some extent, in some of the larger installations in Europe. The advocates of this change argue, that as gas is so largely used for obtaining heat and power, and for lighting purposes, with the incandescent mantle burner, that the thermal value is of more importance to the consumer than is the illuminating value. If this is conceded, it logically follows that in every case where the thermal standard is adopted, the illuminating standard should be eliminated. So far as information is obtainable on this subject, no definite or constant relation has yet been established as between candle-power and thermal value;—considerable variation may occur in either one without corresponding or even relative variation in the other. Any attempt, therefore, to enforce compliance with two standards of manufacture in the present state of the art, would simply result in our being penalized for non-compliance with one, while entirely in compliance with the other. This in itself is a sufficient argument for a single standard.

For some time past, the Institute has had committees on calorimetry. These committees have done much valuable work, and have, from time to time, made their reports. Up to the present, in accordance with their instructions, their work has been confined chiefly to the examination and comparison of the several types of calorimeters on the market; the comparative results to be obtained by the use of the different types, and in formulating rules for the proper method of installing calorimeters and conducting tests.

I believe that the time has now arrived for us to consider the propriety of enlarging the scope of these committees by giving them instructions to take further steps, until, by re-

search and experiment, they are able to make such a report to the Institute, for the information of its members, as to what should be the logical standard of thermal value for the different gases manufactured in different localities; considered from the standpoint of a gas useful for the purposes required, as well as economy in manufacture. A report of this character, well considered and matured, and having the endorsement of the Institute, will have much weight with those who are investigating the subject with a view to making a change of standard, as coming from a body well qualified to give expert advice on the subject. The present committees are now in possession of much useful data and detail information on this subject, and they should be continued.

Another always interesting question is the one that is sometimes called "Government by Commission." Much has been written and said upon this subject, but a few remarks now may not prove out of place. The idea was conceived some years ago, when the National Government placed laws on the statute books, having for their object the regulation and supervision of corporation, especially those corporations classed as Public Utilities Corporations, in which class among others, Gas Companies are included. The lead of the Federal Government was followed by the Legislative bodies of the several states, with the result that many laws were enacted, more or less drastic in character according to the temper of the Legislative bodies at the time, and the demands of so-called public opinion. Public Service Commissions were evolved from among these laws, and they are now exercising their functions in several states. In some localities, and under some laws, these functions are extended to a point dangerously near to control of operation. Public Service Commissions per se are not necessarily harmful or objectionable to corporations. A commission whose members are broad-minded, experienced in business methods, and who will take the time to acquaint themselves with the business of the corporations before attempting to supervise or regulate them, who will recognize the fact that the interests of

the corporations and the public are identical; that disputes or misunderstandings should be amicably settled, and that both have their rights, and among them is the right of the corporation to exist and do business and earn a fair return on the capital invested, such a commission will be beneficial to both corporations and the public. If, on the other hand, a commission be composed of those who are unaccustomed to handling large enterprises, men of narrow minds, or politicians appointed by reason of service rendered to party or person, whose whole conception of the duty of a commission is to make a reason for its existence and continuance, and who, therefore, promote strife as means of gaining notoriety and consequent personal or political advantage, or both, then the result is distinctly bad, not only for the corporation, but also for the customer and the public. "Demanded by Public Opinion" is the shibboleth always used by those interested in procuring legislation favorable to their own interests. If we look into the matter, we find that "public opinion," so-called, is strictly and wholly a manufactured article, manufactured by politicians and others interested in furthering their own or their party schemes, which are ofttimes actually detrimental to public policy and the general welfare of the community. The general public, not having the requisite knowledge to enable them to form definite opinions, are always ready to accept measures that seem on their face to be advantageous to their interests. This being the case, why should we not endeavor to mould public opinion, and, by this means counteract, as far as possible, the effects of false, misleading and garbled statements that are so freely used to our disadvantage. Such a method of procedure is entirely feasible, and can be accomplished by inaugurating a scheme of publicity of the details of our business to such an extent as will satisfy all reasonable people that we are dealing fairly and honestly with them; give out periodical statements or reports in any way or form best suited to reach the public, according to existing conditions in any given locality; in other words, take the public into their confidence, and by this

means create public opinion that is favorable to our interests, in place of an antagonistic feeling, if it exists. An immediate change will not take place, but this course persisted in for a time, will, without question, bring favorable results.

If a Public Service Commission law is enacted and becomes operative in any state, then publicity of every detail of our business will be obligatory. Public opinion will be more in our favor if we do this voluntarily than if it is done under compulsion. It is fair to assume that a system of publicity, inaugurated and carried out in good faith with the public, will be of advantage to any company, by preventing, to a great extent, litigation with its attendant expense and trouble, and make investigations and the enactment of laws prejudicial to the best interests of our industry, much less popular. Another step in the same direction, is to insist that all employees of the company who in any capacity come in personal contact with the public, shall be courteous and avoid giving offense or cause for complaint. Unpleasant relations that are entirely unnecessary between the company and its patrons are readily caused by a disagreeable manner and incivility on the part of clerks and other employees. This is not a matter to be overlooked—discourtesy on the part of the company's employees will easily nullify any efforts of its officers to bring about friendly relations with the public.

From information gathered from different sections, and from the columns of the technical periodicals devoted to the gas industry, we learn that a substantial and most satisfactory increase in the sale of our product has been general over the entire country; and, also, that there is every reason to believe that similar conditions will obtain in the future. Contracts are being made for the erection of new plants in many localities, and for alterations and extensions of existing plants. This is evidence of the healthy condition of our business, notwithstanding the attacks that have been made upon it in the past, and the further fact that the business of our neighbors who are engaged in generating and distributing the electric current is also rapidly, and to them, satisfactorily increasing.

In the early days of gas manufacture, gas was considered to be a luxury; later, when electricity came into the field, that was also a luxury. That time has passed—both are now a necessity, indispensable to the comfort and welfare of our people. Each has its place, its work, and its use. Each will take and hold its place, and the use of each will be constantly on the increase. They will both become more necessary and more indispensable to the entire community as the years roll around. There can be no ground for fearing that either one will or can interfere with the other in its place, work or use, to any appreciable extent, for any appreciable length of time. The public require and demand more light, and more convenient methods of obtaining light than in former days. Gas is being more freely used, and its field of use extended in directions and to an extent never dreamed of in days that are easily within the memory of many of us. But, we must not be content with this, and so cease our efforts to acquire new, and increase our present business over and beyond the natural increase. We must get in touch with our customers. If any are still using the old open-flame burner, now practically discarded and obsolete, see that they are shown the advantage, to them, in the use of the incandescent mantle burner; see that they are supplied with cooking and heating appliances of new and approved pattern and design, at a nominal rental, or nominal cost price, if purchased; see that all appliances are properly installed and adjusted, and that full instruction is given as to their care and use; advertise freely in the local papers, and a large volume of business now lying dormant will be brought into active life. No company is too large or too small to inaugurate a business campaign in this direction—many companies are already in the field,—and in every case with most satisfactory results. Most consumers are pleased with the attention shown them, and every pleased consumer helps, aids and assists by a certain amount of gratuitous advertising among friends and neighbors. Our electric friends have their own methods of gaining business. Their methods are not necessarily competitive, except in the one field of light-

ing. There we must endeavor, so far as possible, to hold our own through the greater volume of light obtained per unit by the use of the incandescent mantle, if it comes to competition.

Another advantage to be gained from a general use of gas for purposes other than lighting is, that the consumption is spread more uniformly over the twenty-four hours of the day. In some cases where there is a considerable increase in the use of gas for cooking and heating, the daylight output is gaining rapidly, and approximates fairly well with the output during the hours when darkness prevails. This also has a beneficial effect on manufacturing and storage conditions.

The members of the National Commercial Association are our active allies along these lines. It is their business to introduce appliances. It is our business to provide use for them. Much more could be said on this and kindred subjects, but I have already consumed more time than I allotted to myself, and will close with a short resumé of the work of the Institute for the past year.

The report of the Treasurer shows an improved financial condition, the treasury having a substantial surplus, with no outstanding liabilities of consequence.

The report of the Secretary shows a net gain in membership of sixteen, making a total to date, of 1,348 members.

During the year, eighty-seven new members were elected, and seventy-one were lost through resignation, death, and by being dropped from the roll, as is found fully itemized in the report. The work of the several standing committees has been well and faithfully performed so far as it was within their power to perform it; notably the Committee on Standardizing Cast Iron Pipe, which has been held over for several years. The Technical Committee have done an immense amount of work, as will be shown in the reports to follow, and in the number and character of the papers obtained.

With reference to committee work,—I would suggest, that in the future, when committees are formed for special work or

research, that they be continued intact, so far as is possible, until the completion of their work. Much time is wasted by the appointment of new committees to take up unfinished work, or by change in the membership of existing committees, owing to the necessity of completely reviewing all previous work before attempting to make progress.

Another suggestion is, that when mandatory resolutions are passed, directing the appointment of a committee, or delegate, for any purpose that will involve the expenditure of an amount of money to carry out the purpose of the resolution that, coupled with the resolution, some provision should be made, or authority given, by which an amount sufficient to defray the necessary expense can be had, in order to prevent embarrassing situations in the future.

The grim reaper, death, has made an unusual harvest from among our ranks, since our last meeting, exacting from us a toll of no less than eleven members; nine of them being on the roll of active members; one associate; and one junior member as follows:—

Moses Coombs	Active	Died	March	13, 1909
Thos. J. Hayward,	"	"	October	23, 1909
Geo. M. Witherden,	Associate	"	December	—, 1909
John Fred'k Klug,	Junior	"	January	2, 1910
W. B. Clements,	Active	"	January	6, 1910
A. T. Averill,	"	"	April	—, 1910
Jas. B. McGowan,	"	"	April	25, 1910
Wm. Henry Smith	"	"	May	16, 1910
O. F. Greim,	"	"	June	6, 1910
Thos. O. Horton,	"	"	June	13, 1910
W. A. Stadelman,	"	"	July	6, 1910

We are but rarely called upon to record in the brief space of one year, the loss of so many of our associates. The loss to the Institute is great, but greater still is the loss to those of us who were privileged to know them intimately. Perhaps the one who had the largest circle of acquaintances among us was Mr. Thomas J. Hayward, whose death oc-

curred just after the close of the Detroit meeting of last year. His was a distinct loss to the whole profession—of commanding presence—most charming personality—always genial and pleasant in his intercourse with us; always helpful and resourceful in business; never refusing to aid with advice and substantial assistance when appealed to. He will long be remembered by the many who were so fortunate as to be numbered among his intimate acquaintances.

The reading of the President's address was concluded with great applause.

THE VICE-PRESIDENT: Gentlemen, you have heard the reading of the President's address. It has been the custom to refer the President's address to a Committee. If there is no objection, this will be done. The Committee will consist of Colonel E. G. Pratt, Mr. Paul Doty and Mr. John Williamson.

The President then resumed the Chair.

REPORT OF NOMINATING COMMITTEE.

THE PRESIDENT: The next order of business is the report of the Nominating Committee, for officers for next year. Is the Nominating Committee ready to report? Capt. McKay is the Chairman of the Committee.

Capt. McKay then read the following report:

NOMINATING COMMITTEE.

The Committee reports that two of its members have been unable to come to New York. We have communicated with these absent members, and are awaiting their reply. As a telegram from San Francisco cannot be expected before 1:00 P. M. we request permission to present our further report at 2:30 P. M., this afternoon.

WILLIAM E. MCKAY,
Chairman.

THE PRESIDENT: If there is no objection, the report of the Nominating Committee will be made the order of busi-

ness at 2:30 P. M. I will appoint as Tellers, when the Nominating Committee make their report, Mr. C. H. Nettleton, Mr. G. H. Woodall and Mr. T. D. Miller.

PLACE OF NEXT MEETING.

THE PRESIDENT: I will also appoint as a committee on the next place of meeting Mr. A. E. Forstall, Mr. J. M. Morehead and Mr. J. W. Dunbar.

REPORT OF PUBLIC RELATIONS COMMITTEE.

THE PRESIDENT: Passing over the election of officers, the next order of business is the report of the Committee on Public Relations.

Mr. Nettleton, the Chairman of the Committee, asked the Secretary to read the report, and the latter read the same as follows:—

The Committee on Public Relations would respectfully report that no matter has been referred to them during the past year. Some matters were considered, but for various reasons it was thought best not to submit a statement in regard to same.

CHARLES H. NETTLETON,
J. L. RICHARDS,
WILLIAM F. HART,
DONALD MCDONALD,
RUFUS C. DAWES,
JAMES T. LYNN,
Committee.

THE PRESIDENT: If there is no objection the Report of the Public Relations Committee will be received and placed on file. Hearing none, it is so ordered.

REPORT OF TECHNICAL COMMITTEE.

This report was read by the Secretary, on the request of Mr. W. Cullen Morris, the Chairman, as follows:—

On behalf of the Technical Committee of the American Gas Institute, I beg to report that we have presented a list of

papers which are shown on your programs, also several reports of sub-committees which will be presented by the respective chairman of the committees.

Respectfully submitted,

W. Cullen Morris, Chairman.

The President: The Report of the Technical Committee was embodied in the Report of the Directors. Next we will have the Report of the Committee on Calorimetry.

The Report was then read by the Chairman, Mr. John B. Klumpp, as follows:—

REPORT OF CALORIMETRY COMMITTEE.

During the last two years your Committee undertook an investigation of the subject of Gas Calorimetry, with the view of ascertaining the best commercial methods for obtaining the calorific value of city illuminating gas. With this object in view, they obtained calorimeters of the prevailing makes then in use by the gas companies and other gas industries, and undertook to determine the efficiency and general utility value of these instruments. The reports submitted by your Committees in 1908 and 1909 described in detail the line of investigation undertaken and the results obtained, and up to this time we have no further knowledge that would tend to modify our conclusions. These conclusions were, briefly, that calorimeters of the water heater, or Junkers, type were best suited for commercial practice, and when operated under certain prescribed directions they should give results that could be accepted as the relative calorific value of any gas.

The object of continuing this Committee was for the purpose of investigating any further development in gas calorimetry, as several instrument makers signified their intention to manufacture gas calorimeters differing in principle and design from those now in use; therefore it has been the task of your Committee to keep posted in this line of work, not to recommend or condemn but to advise members of the

Institute as to a type of calorimeter best suited for use in the Gas Industry.

Unfortunately, several very interesting types of instruments were received as late as the first week in September, and the time has been too short for us to conduct experiments that could be presented in full at this meeting.

Professor S. W. Parr, of the University of Illinois, concluded during the past year some experimental work upon the Junkers Calorimeter, and submitted the results of his work to the American Chemical Society, and his article on this subject was recently published in the September number of the *Journal of Industrial and Engineering Chemistry*. He claims that the Junkers Calorimeter gives results too low by from 1 per cent. to 4 per cent. when operated with circulating water of the same temperature as that of the air, which he determined by burning pure hydrogen in the calorimeter. These figures are not in accord with experiments of Hugo Junkers, or of Dr. Immenkotter, and do not agree with our efficiency tests. Professor Parr claims that the errors are due to atmospheric humidity and radiation, and your Committee is not ready to accept his criticisms without further investigation.

Professor Parr has submitted to us a calorimeter of his own design, depending upon the comparison of the unknown gas to be measured with hydrogen of assumed heating value. This instrument is a duplex calorimeter, one side burning the city gas, while the other side burns the hydrogen. The ratio of the heating value of the gases is determined, and this factor is used to give the value to the unknown gas being measured.

The American Meter Company has produced a gas calorimeter of the same general design and specifications are the Junkers. This instrument is modified, however, so as to have the thermometers on the same level, and is supplied with a gas meter of their own make, and a balance for weighing the circulating water. This instrument, with its acces-

sories, is constructed in accordance with the recommendations of your Committee.

The Junkers Company, of Dessau, Germany, has also modified their calorimeter, producing a later instrument with the water thermometers on the same level. The entire outfit is arranged similar to the original Junkers, although the interior of the calorimeter proper is slightly altered, and the arrangement of the exterior connections somewhat changed.

They have also produced a recording calorimeter, mounted in a cabinet, which maintains an even ratio between the gas and water supplied, and records the difference in temperature of the inlet and outlet water, electrically. This instrument is somewhat elaborate, and requires careful adjustment and supervision, but in the larger works could be made to give very satisfactory results.

During the month of September we received for experimental purposes a Doherty calorimeter, from the Improved Equipment Co., of New York, an instrument of the water heater type, with gas measured by water displacement, the water at the same time being used for jacketing purposes. This instrument is undergoing tests, the results of which are not as yet completed.

We have received word from several other parties who were about completing calorimeters, or have them in view, pending the granting of patents, or completion of design, and who up to the present time have been unable to submit instruments to us. They include the Rotary Meter Company and Dr. C. E. Lucke, of Columbia College.

While not engaged in active experimental work this year, owing to the lack of instruments to work with, we have consulted with various members of the Gas Institute for the purpose of receiving information in regard to the practice of others, and have in addition been called in consultation with several state gas associations, and the engineers of state commissions, and have endeavored to assist and advise in matters pertaining to the correct reading of calorific value of commercial city gas.

Your Committee has been asked by several members of the Institute for concise directions for operating a gas calorimeter, and it refers to the directions in the Calorimeter Report, on page 316 of the Proceedings of the Institute for the year 1908, which go into considerable detail. The 1909 report gives further specifications, especially in regard to the thermometers to be recommended for measuring the temperature of the water, which should be graduated preferably from 60° to 110°, instead of 65 to 115°, as stated.

While we are not in a position at this time to present the results of our experimental work on new calorimeters, we are endeavoring to obtain unbiased and correct data on such calorimeters as appear on the market, and if our Committee is continued for another year will attempt to collect further information for the Institute.

R. B. Brown,
C. F. Burgess,
R. C. Cornish,
O. L. Kowalke,
J. B. Klumpp, Chairman.

The President: Gentlemen, you have heard the report as made to the Directors and approved by them. What is your pleasure?

A motion was made, seconded and carried that the Report be accepted and placed on file and that the Committee be continued.

REPORT OF THE COMMITTEE ON THERMAL VALUES AND CANDLE-POWER.

The Report of the Committee was then read by Dr. Humphreys, Chairman, as follows:—

This Committee has kept itself informed as to what has been done by the various gas companies, associations, and Committees representing such municipalities and states as have taken up a consideration of this important subject. The Committee feels that it is not ready to make a report that will state definite conclusions, believing that it would be wiser

to allow the intelligent study that is now being given to the subject by the associations, companies and regular commissioners to make further progress.

We believe the Institute will be gratified to learn that the definition of heating value of a gas promulgated by a former Committee of this Institute and adopted by the Institute has been accepted by the joint Committee on Calorimetry representing the Public Service Commission and Gas Corporations in the Second Public Service District in New York State, and that the report of this Committee on the equipment of calorimeters and method of operation agrees substantially with the rules promulgated by the Institute's standing Committee on Calorimetry.

Your Committee recommends that this Committee's work be continued.

A. C. Humphreys, Chairman,
A. H. Elliott,
W. H. Gartley,
R. M. Searle,
J. M. Morehead,
J. B. Klumpp,
J. F. Wing.

A motion was made, seconded and carried that the report be received and placed on file, and that the Committee be continued.

The President: Next is the

REPORT OF THE COMMITTEE ON CONSUMERS' METERS.

Mr. Schiller, Chairman.

As Mr. Schiller does not appear to be here, the Secretary will read the Report.

The Secretary then read the report as follows:—

Your Committee, since its appointment has had two meetings, and on these occasions a large amount of data and some carefully prepared communications have been submitted to the individual members of the Committee.

The obvious difficulty of digesting this data and of condensing the information submitted, leads your Committee to submit a report of progress only, and to ask that further time be allowed for consideration of the subject, provided the same meets with your approval.

CHAS. C. SCHILLER, Chairman,
WM. A. CASTOR,
DONALD MCDONALD,
A. K. HARRINGTON.

A motion was made, seconded and carried that the Report be received and placed on file and that the Committee be continued.

THE PRESIDENT: Next in order is the

REPORT OF THE WRINKLE DEPARTMENT.

Mr. Richard C. Congdon, Editor.

MR. CONGDON: I think I have written to every member. If I have missed any of you please accept my apology. I want to thank all of you who have answered my letters, whether you sent in any wrinkles or not; but I want to specially thank those whose letters were accompanied by wrinkles. We are especially indebted to President Bradley and his assistants for the work they have done, as you will note from the report, for they have contributed nearly forty per cent. of the wrinkles submitted.

Some of these wrinkles exhibit methods long since adopted by a good many of us, but I was not sure whether or not they had ever been printed, so I included them in the list. I have a number of wrinkles which were received too late for this report, and these I shall be pleased to turn over to the next editor. My experience as editor of the Wrinkle Department has demonstrated to me that it is not necessary to

depend upon your friends alone, for I have found, you can rely upon the loyalty of the members of this body. You have a copy of the report, which I hope meets with your approval.

WRINKLES—1910.

SUBMITTED FOR THE FIFTH ANNUAL MEETING OF THE AMERICAN GAS INSTITUTE, 1910, BY R. C. CONGDON, EDITOR.

TOOL CART FOR STREET MAIN WORK.

This cart can be moved along the line of trench as the work progresses; or a horse can be attached when the cart is to be moved a long distance.

GEORGE BEADENKOPF, Engineer,

Consolidated Gas Electric Light & Power Co. of Baltimore.

Ill. No. 1.

LANTERN BOX.

The accompanying illustrations show two views of the Lantern Box, open and closed.

The lanterns when removed from the trench in the morning are cleaned, refilled and placed in the lantern box, thus facilitating handling a large number of lanterns and preventing breakage.

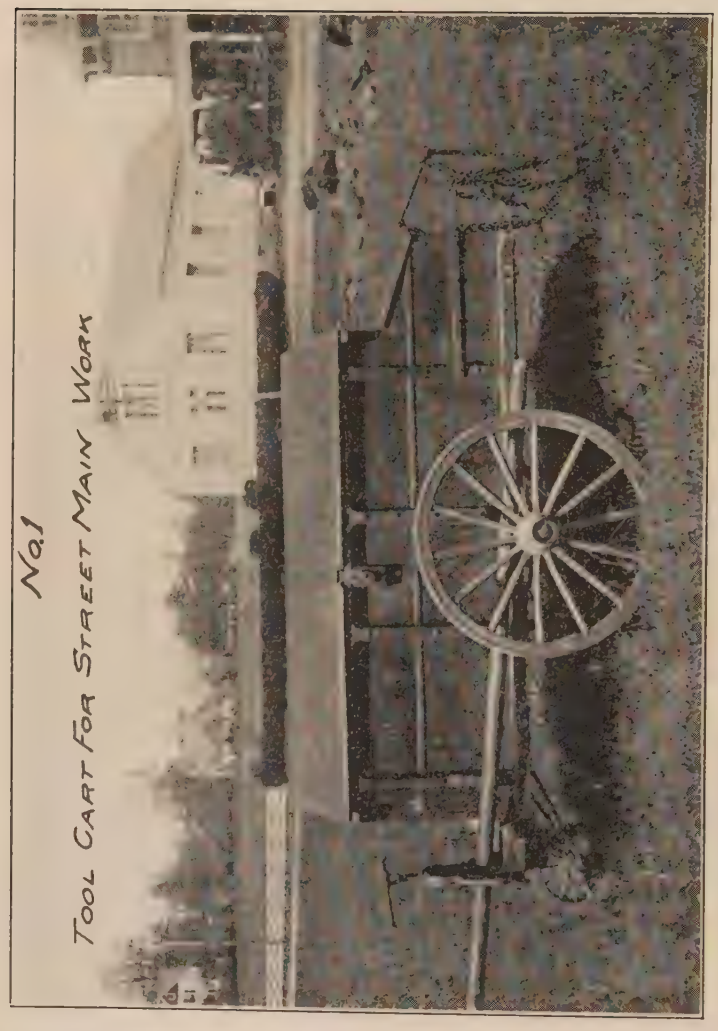
GEORGE BEADENKOPF, Engineer,

Consolidated Gas Electric Light & Power Co. of Baltimore.

Ill. Nos. 2 and 3.

PORTABLE HOUSE FOR STREET WORK.

Two views show a portable house for watchman and for temporary storage of material; one showing the house set up



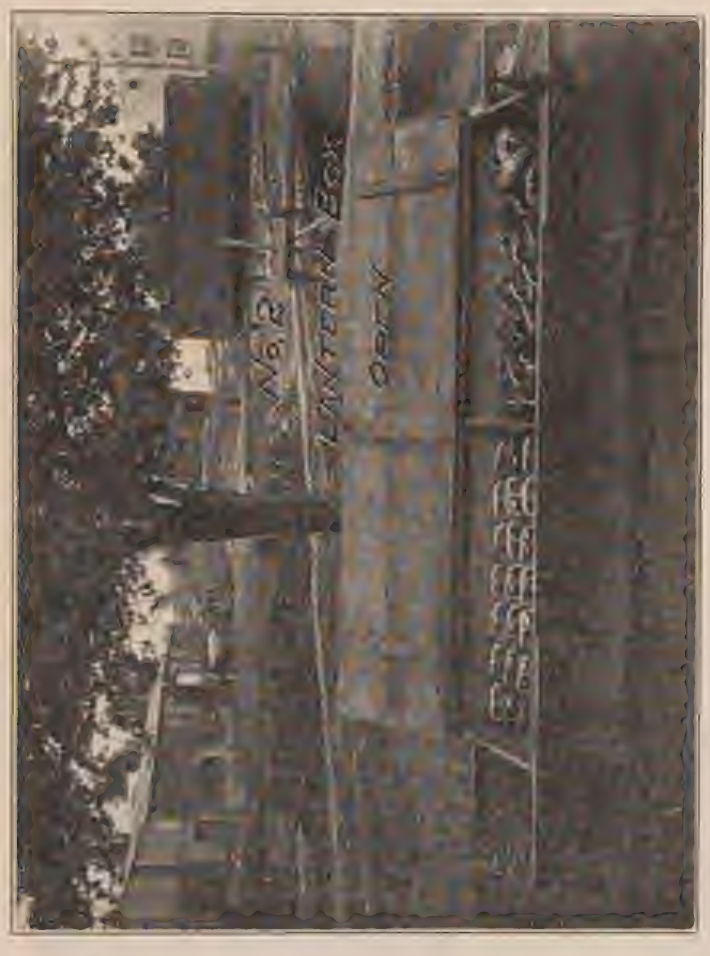
Ill. No. 1.

and the other taken apart for moving. It is bolted together, and can be set up or taken apart in a very few minutes.

GEORGE BEADENKOPF, Engineer,
Consolidated Gas Electric Light & Power Co. of Baltimore.
Ill. Nos. 4 and 5.

ADVERTISEMENT FOR DAY AND NIGHT.

Three outside Lucas lamps are suspended from the tank, illuminating the sign at night.

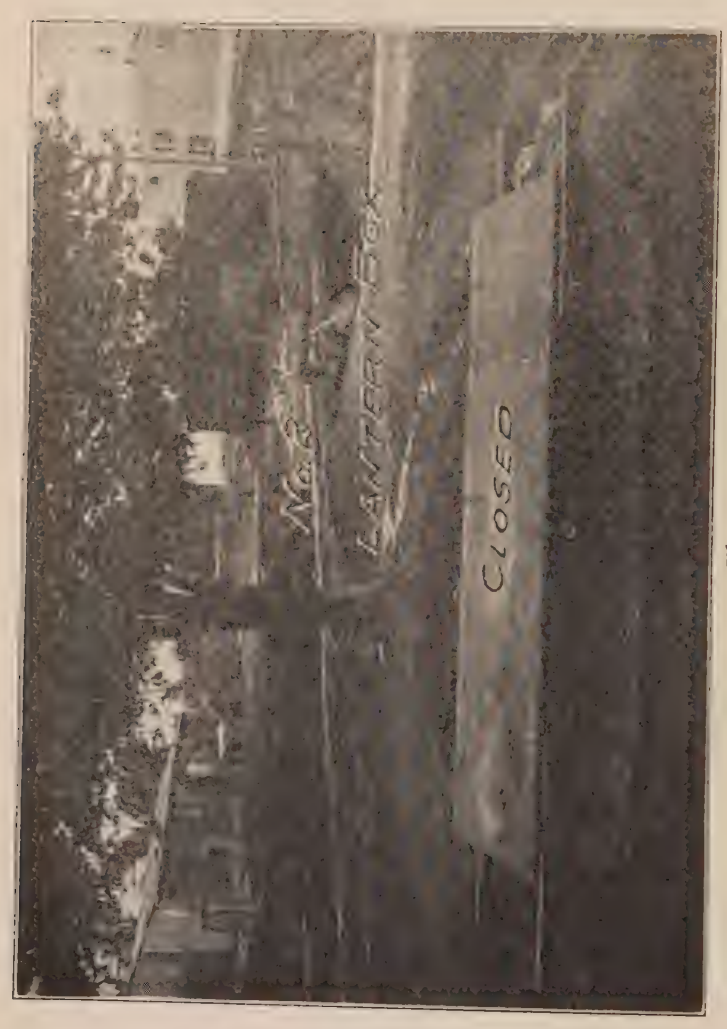


Ill. No. 2.

GEORGE BEADENKOPF, Engineer,
Consolidated Gas Electric Light & Power Co. of Baltimore.
Ill. Nos. 6, 7 and 8.

AUTOMOBILE FOR DISTRIBUTION WORK.

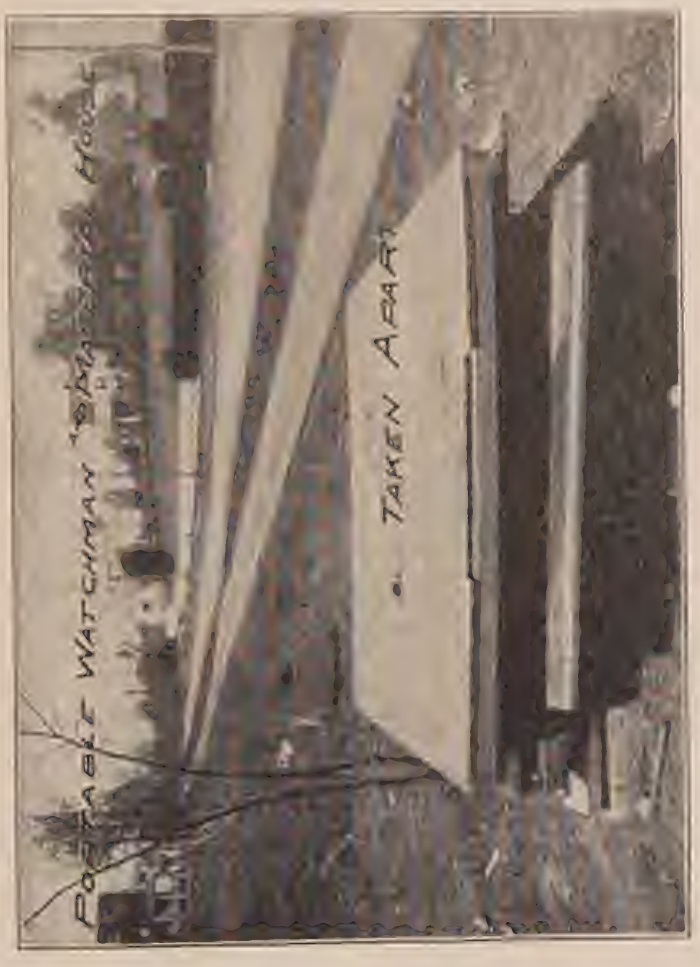
The Illustrations show the automobile equipped with a pres-



Ill. No. 3.

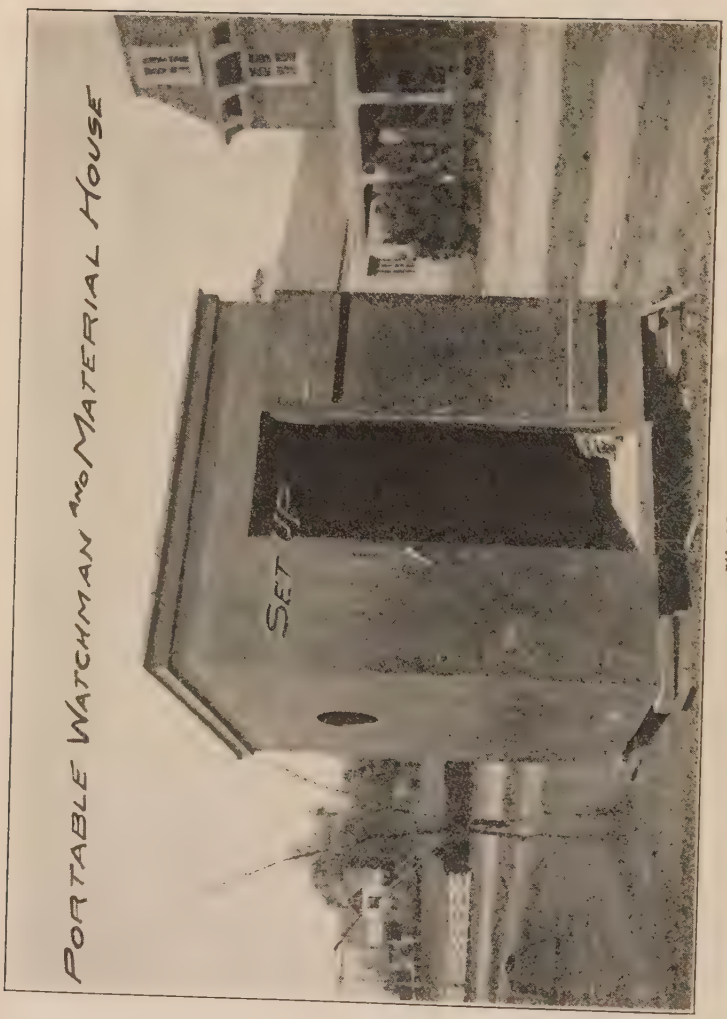
sure blower, used for pumping up and testing long lines of newly laid mains. The automobile serves the double purpose

of traveling from place to place quickly and furnishes motive power for driving the blower.



Ill. No. 4.

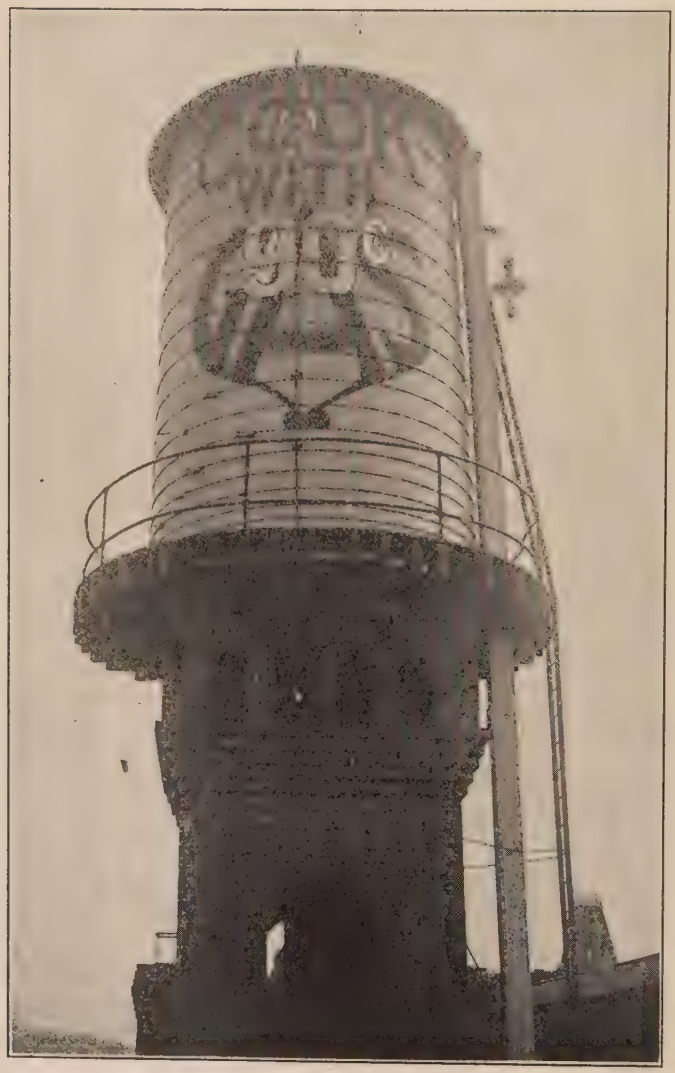
Illustration No. 9, is a side view showing the automobile with sprocket chain connected from automobile engine to the blower in the wagon.



Ill. No. 5.

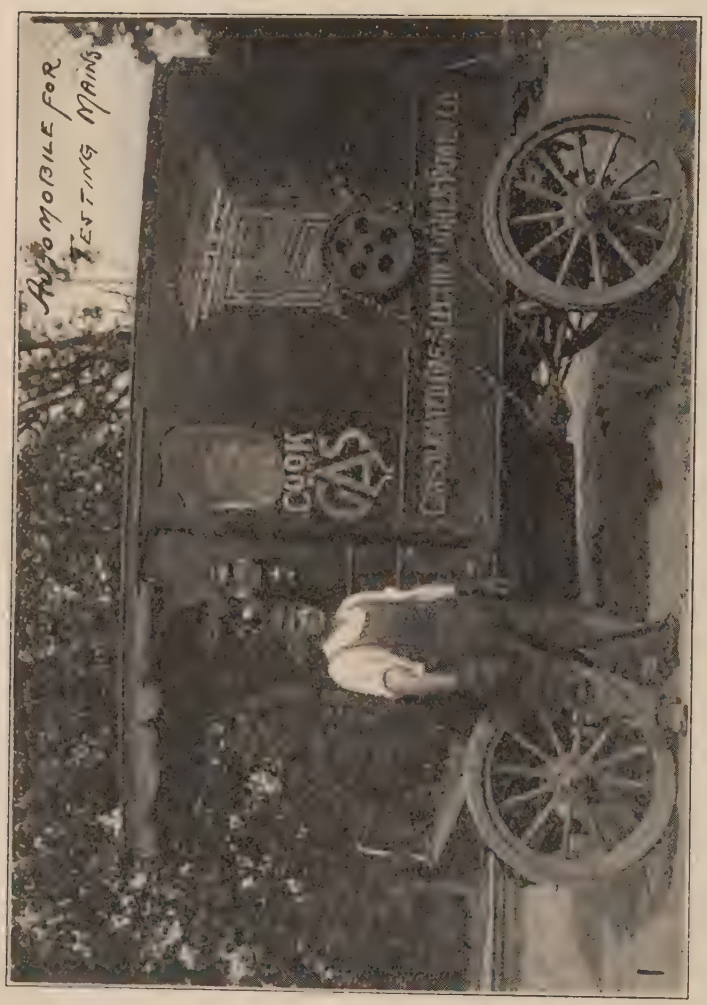
Illustration No. 10 shows equipment connected with a hose to the main to be pumped up.

Ill. No. 6.



Ill. No. 7.

Ill. No. 8.



Ill. No. 9.

Illustration No. 11, shows a view of the blower in the wagon.

GEORGE BEADENKOPF, Engineer,
Consolidated Gas Electric Light & Power Co. of Baltimore.
Ill. Nos. 9, 10 and 11.

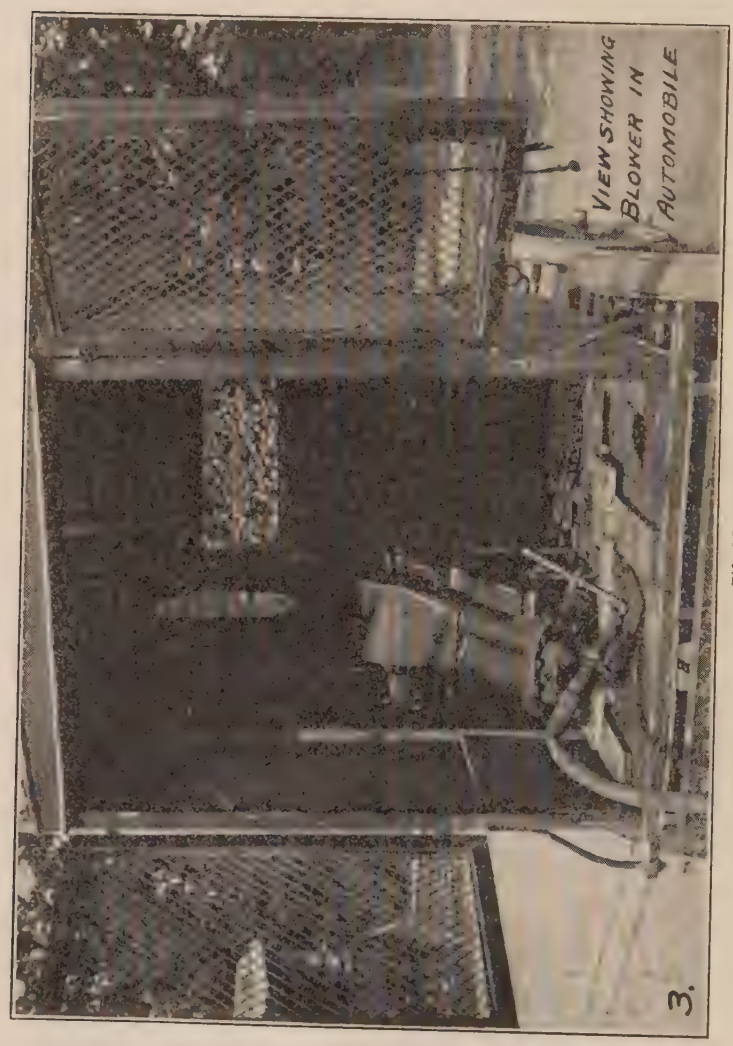
A HEAD USED IN CONNECTION WITH TESTING NEWLY LAID MAINS.

The head has attached to it a rubber gasket and is clamped

Ill. No. 10.

to the face of the bell; an iron strap runs around the back of

the bell, to which the clamping bolts are secured. This head



Ill. No. 11.

can be put on and taken off more quickly than by the old method of the cast iron plug roped into the bell; it is especially

Ill. No. 12.

applicable to large size mains. The accompanying drawings and illustrations clearly show the design of this head.

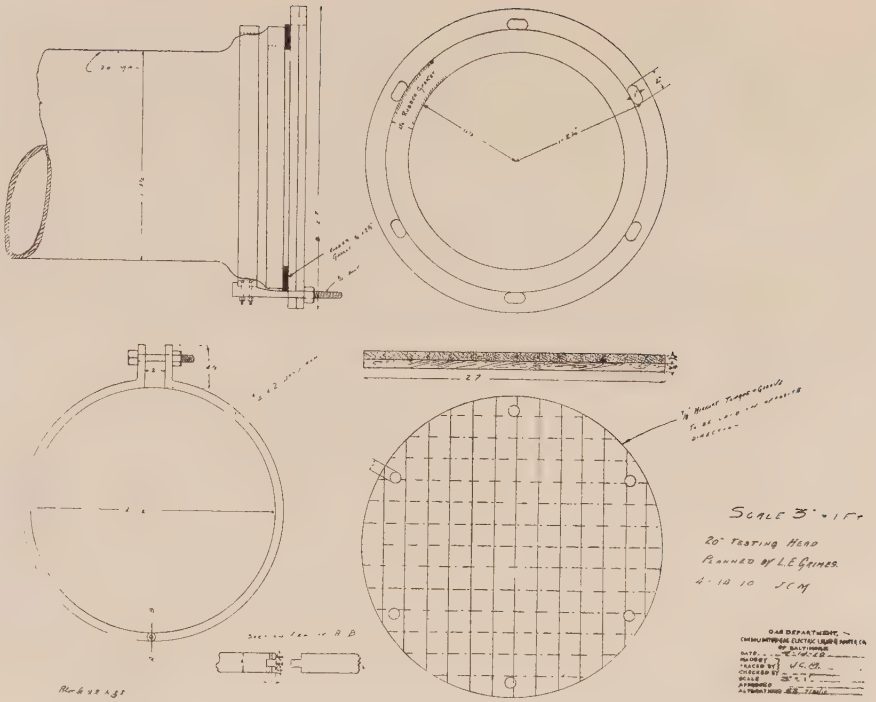
GEORGE BEADENKOPF, Engineer,
Consolidated Gas Electric Light & Power Co. of Baltimore.
Ill. Nos. 12, 13 and 14.

APPARATUS USED FOR TAPPING LARGE MAINS.

The photograph shows a contrivance used for tapping large

Ill. No. 13.

mains, especially those that are deep. It obviates the necessity of digging down under the main to get the chain around it for holding down the tapping machine.



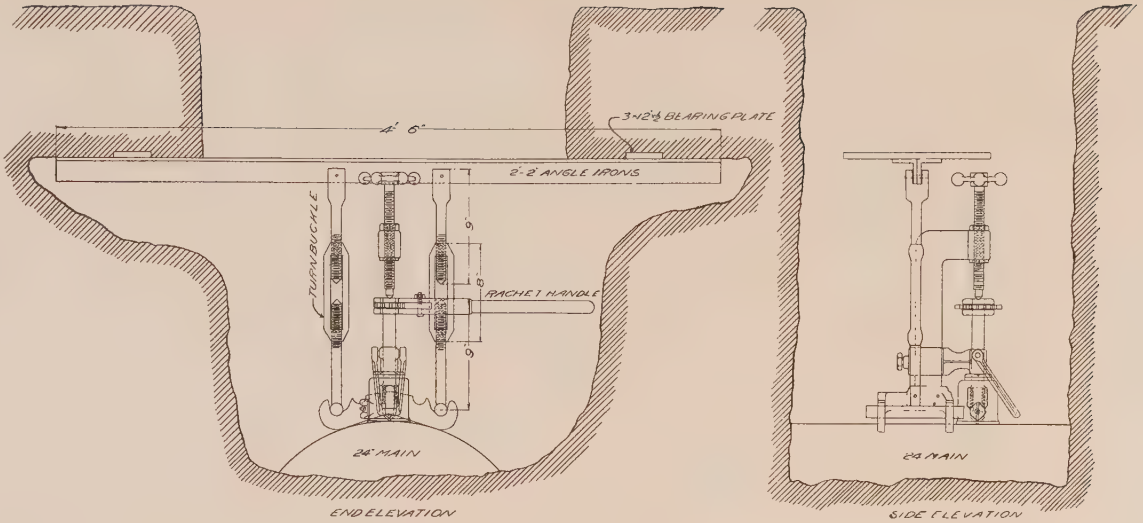
Ill. No. 14.

An angle iron is thrown across the trench over the tap-

RIG FOR TAPPING MACHINE USED ON LARGE MAINS.

Ill. No. 15.

ping machine, to which two turn buckles are attached acting as



CONTRIVANCE TO BE USED WITH
A TAPPING MACHINE TO PREVENT
EXCAVATING AROUND THE SIDES AND
BOTTOM OF LARGE MAINS IN ORDER TO
FASTEN THE MACHINE WHILE TAPPING.

SCALE 3"-1'

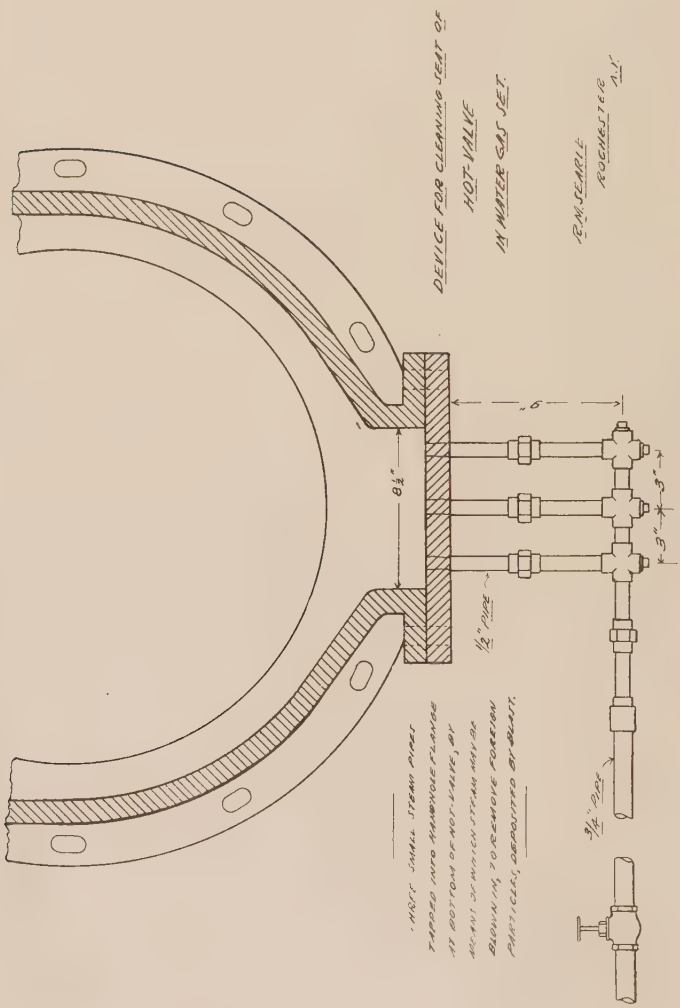
PLANNED BY
L. W. HERBST

GAS DEPARTMENT,
CONSOLIDATED GAS ELECTRIC LIGHT & POWER CO.
OF BALTIMORE.
DATE 7-20-10
MADE BY
TRACED BY
CHECKED BY
SCALE 3"-1'
APPROVED
ALTERATIONS

Ill. No. 16.

thrust rods to hold down the tapping machine. Considerable time can be saved by the use of this machine.

GEORGE BEADENKOPF, Engineer,
Consolidated Gas Electric Light & Power Co. of Baltimore.
Ill. Nos. 15 and 16.



Ill. No. 17.

DEVICE FOR CLEANING SEAT OF HOT VALVE.

Heretofore, we have had considerable loss of time and loss of capacity of set, due to the necessity of cleaning particles of coal, etc., from the bottom of the hot valve. Our Foreman put 3 ½ in. Nipples in bottom of Hot Valve to blow out accumulation, as shown in illustration—"Device for cleaning seat of hot valve in water gas set."

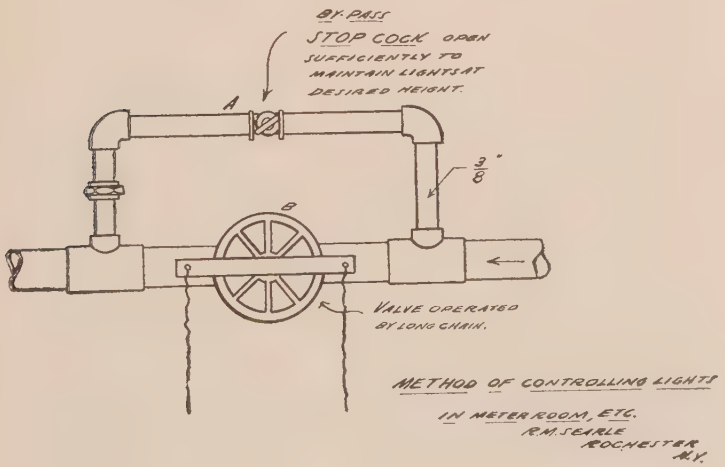
During the blow the steam is turned on and all the dust and particles of coal are blown from hot valve over into carburetor by the blast gases. We have not had the plate off the bottom of the hot valve for several months.

R. M. Searle,
Rochester, N. Y.

Ill. No. 17.

METHOD FOR CONTROLLING GAS LIGHTS.

In an endeavor to cut out the gas in rooms where gas light



Ill. No. 18.

is needed intermittently, the accompanying wrinkle was installed.

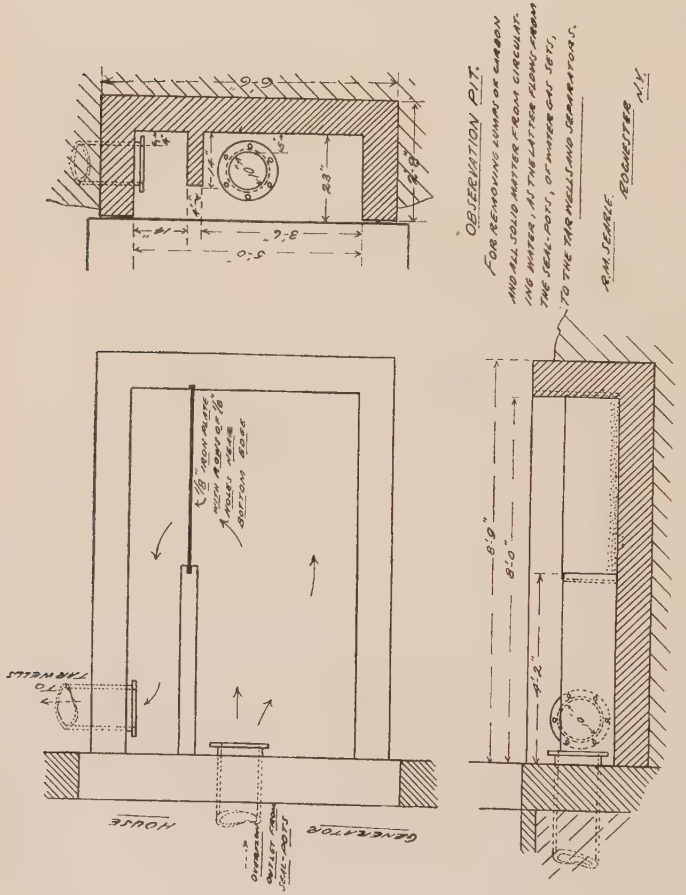
The main line has a valve "B" cut in and valve "B" has a

by-pass controlled by Cock "A." Cock "A" is adjusted to maintain the lights in a room at lowest safety point. When all the lights are needed, valve "B" is thrown open putting full pressure on the main line.

This wrinkle has cut the gas consumption in a number of rooms in the different parts of the works about 50 per cent.

R. M. Searle,
Rochester, N. Y.

Ill. No. 18.


OBSERVATION PIT.
FOR REMOVING LIME OR CARBON AND ALL SOLID MATTER FROM CIRCULATING WATER; AT THE LATTER POINT FROM THE SEAL-POT, OR WHERE GAS SETS, TO THE TAR WELLS AND SEPARATORS.
R.M. SEARLE.
ROCHESTER N.Y.
8'-9"
8'-0"
4'-2"
HOUSE
GENERATOR
TAR WELLS

Ill. No. 19.

OBSERVATION PIT.

This is designed to get at quality of Tar being made and screen from the wash box water and tar, small particles of carbon that ordinarily get into separators clogging pumps and causing unnecessary stoppage and repair.

This has been found very useful and economical. Of course, this pit can be located anywhere in the main line of wash-box overflow, of any water gas plant.

R. M. Searle,
Rochester, N. Y.

Ill. No. 19.

DEVICE TO PREVENT COLLAPSE OF CROWN OF RELIEF HOLDER WHEN RUN TOO LOW.

The illustration accompanying this wrinkle is self explanatory.

R. M. Searle,
Rochester, N. Y.

Ill. No. 20.

ROPE DRIVE FOR PUMPING YARD DRIPS.

To avoid freezing of pipes, water in engines, maintenance, etc., a Rope Drive was designed for heaviest drip in our yard which is some distance from engine room. This method of pumping drip is so economical and satisfactory that a rope drive outfit for this purpose is worth putting on record.

R. M. Searle,
Rochester, N. Y.

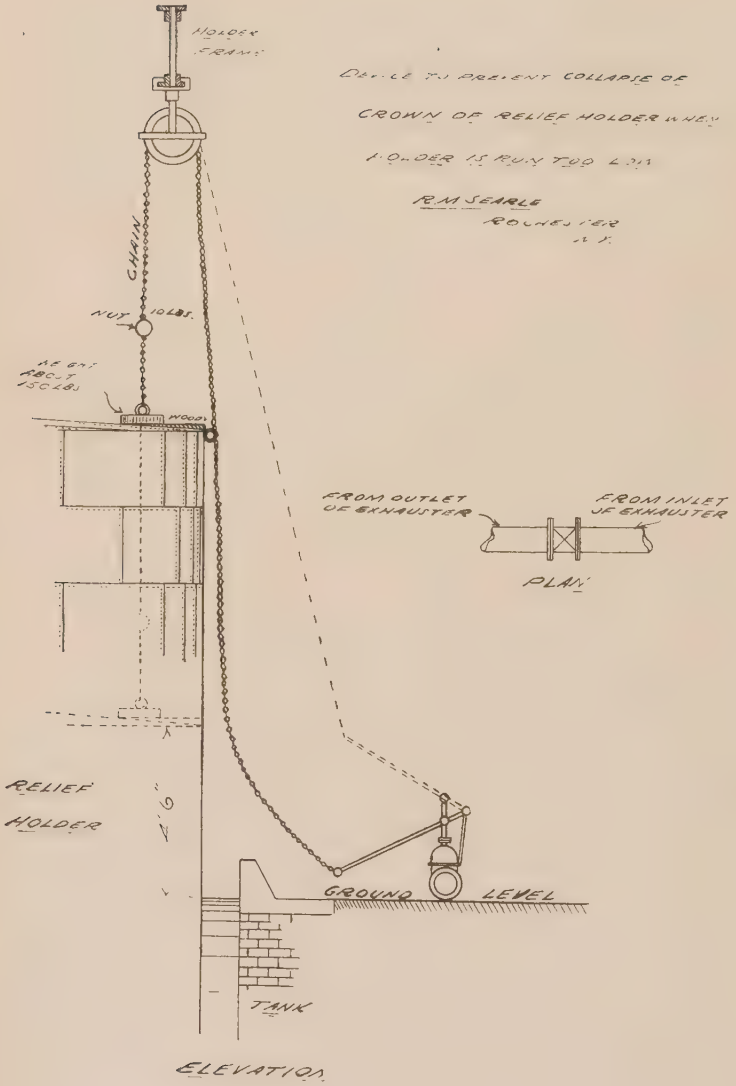
Ill. No. 21.

PORTABLE SCAFFOLD.

This is in use at Westchester Lighting Company's Pelham Works. Drawing "Movable Scaffold" explains the use of same very fully.

R. M. Searle,
Rochester, N. Y.

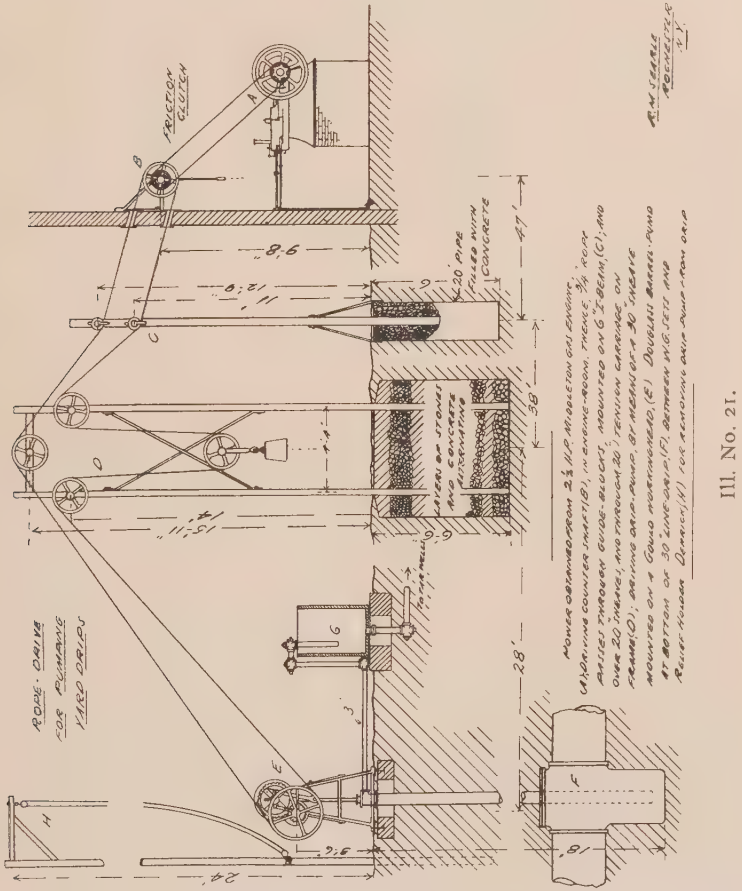
Ill. No. 22.


HOLDER FRAME
CHAIN
NUT
10 LBS.
ABOUT 150 LBS.
WOOD
FROM OUTLET OF EXHAUSTER
FROM INLET OF EXHAUSTER
PLAN
RELIEF HOLDER
GROUND LEVEL
TANK
ELEVATION

Ill. No. 20.

METHOD OF BURNING PITCH UNDER BOILERS.

We have tried a good many plans for burning pitch under our boilers, but have found the actual problem of getting the pitch into the furnace a rather troublesome one. If it is

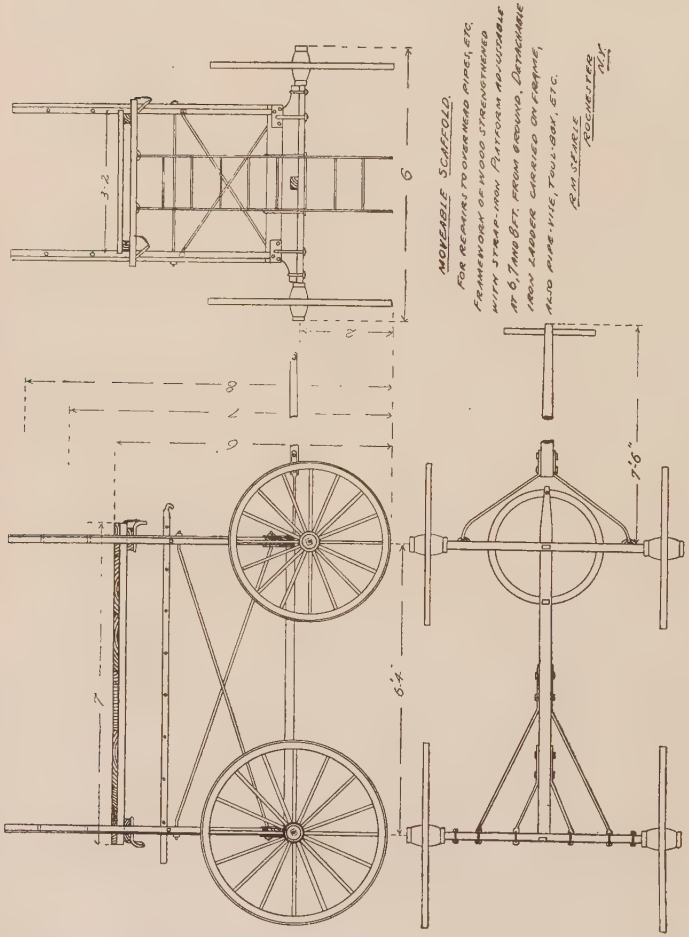


Ill. No. 21.

mixed with breeze, the cakes of breeze and pitch cement together, and must be cut apart again.

We have found the easiest plan to be to cut the pitch into chunks which will weigh about ten pounds each. Wrap

these in paper, and throw them into the boiler without the use of a shovel. Old newspapers or any other paper will answer,



Ill. No. 22.

but heavy paper which is not softened too much by a little water is the best. These packages can be made up, loaded on a barrow until they are wanted, and thrown into the boiler fire in a few minutes without causing any dirt on the boiler

house floor, and without any disagreeable labor to anyone except the man who makes up the packages.

Donald McDonald, President,
Kentucky Heating Company, Louisville, Ky.

BOILER HOUSE ESPECIALLY DESIGNED FOR BURNING COKE BREEZE.

Coke breeze is a lean fuel, and therefore requires a very large grate surface in order to burn enough of it to evaporate the water required.

It is a very close fuel, and hence requires a strong draft to force the air through the fuel bed.

No automatic stoker will burn coke breeze, as the principle of all automatic stokers is to present a clean grate to the fuel, and if a clean grate is presented to the breeze, it will fall through.

Keeping these principles in mind, we built our plant as follows:—A concrete stack 6 feet in diameter and 160 feet high furnishes the draft. The boilers are horizontal fire tube boilers, 150 H. P. each. They are set with Dutch ovens, the fire box being 7 feet wide and 8 feet deep. The breeze is received into bins on top of the boiler house, and spouted through 10 inch wrought iron pipes through two openings in the top of each Dutch oven. In this way the fireman is not required to shovel any fuel but only to spread out the breeze after it has come down through the spouts. The fire boxes are so large that it is not necessary to force the fires, and in this way the temperature at which ash will melt and form a clinker is rarely reached.

We have no difficulty about burning pitch in these boilers. The draft is so strong that very little smoke is made, and the boilers are set high above the grate bars, so that there is no danger of burning them up with the intense heat of the pitch fire.

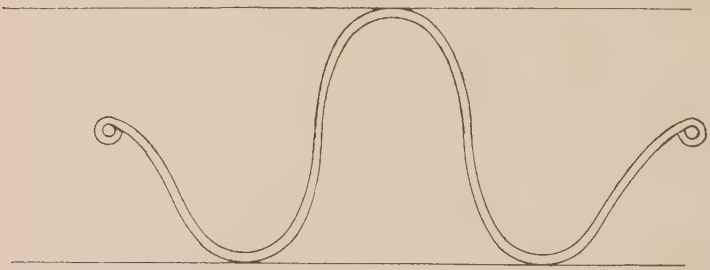
In investigating this subject, I found a great many places where breeze was mixed with coal and burned with automatic

stokers. I did not find any place where breeze alone was burned. Our plant has now been in very satisfactory use for about two months, and I give you the above outline of the principles on which it is constructed, thinking that it may be of some use to someone else who is confronted with the same problem.

DONALD MACDONALD, President,
Kentucky Heating Company, Louisville, Ky.

SPIRAL PIPE CLEANER.

"An obstruction developed in a 20 inch pipe in a place which was very difficult to get to. There was no open elbow through which any large cleaner could be inserted. After thinking over a great many plans, we drilled a 2 inch hole at an elbow, passed a strong cord through the pipe and inserted a cleaner shaped like a cork screw, with an eye on each end to which a line could be attached. You will see at once that



SPIRAL PIPE CLEANER.

To pass through a 2 inch hole and clean out large pipe.

DONALD MCDONALD,
Louisville, Ky.

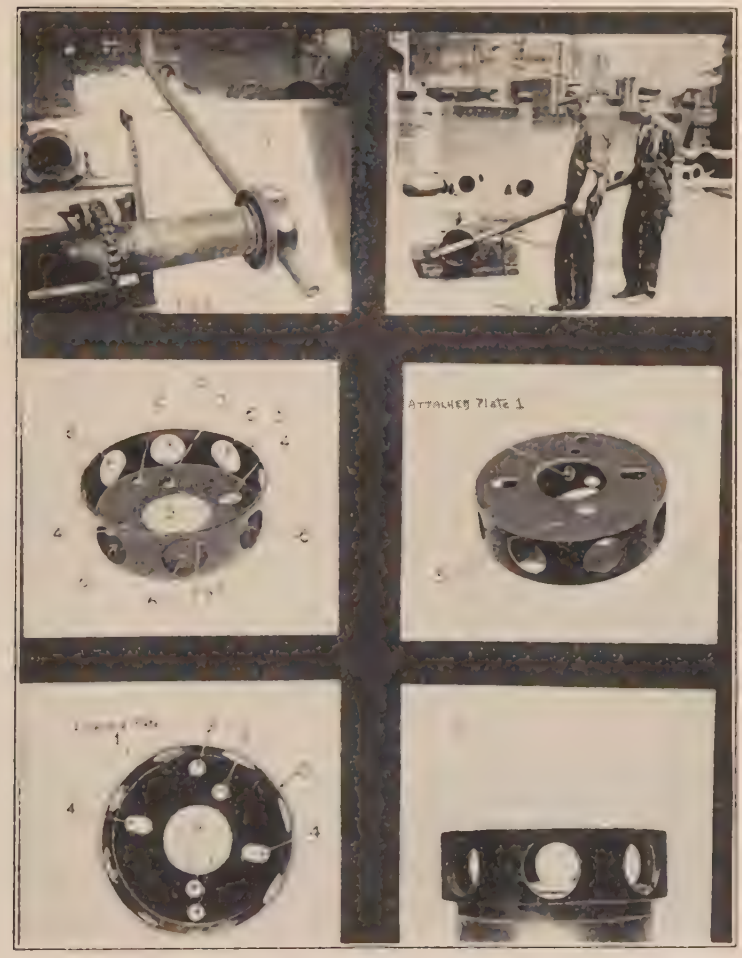
Ill. No. 23.

a device of this shape can be wriggled through a 2-inch hole, and will at the same time clean a 20 inch or even a larger pipe.

In case it meets with heavy obstruction, the spiral will stretch and will pass, and by drawing it over the obstruction several times, the obstruction can be removed."

DONALD McDONALD, President,
Kentucky Heating Company, Louisville, Ky.

Ill. No. 23.



Ill. No. 24.

Ill. No. 25.

STRONG UTILITY WRENCH.

The accompanying illustrations show the wrench and its application.

Ill. No. 26

The wrench consists of a single casting of malleable iron,

light enough to be easily handled and strong enough to remove a flange set by service and peined on by the steam fitter.

Ill. No. 27.

(We have at our works used the wrench for taking down steam lines put up in this manner.)

The bed plate is drilled in such a manner as to permit the same wrench to be bolted to several different sizes of flanges. The rim is provided with openings which enable the user to operate the wrench from any angle or in out of the way places. The jaws are bolted to the bed plate and are adjustable to any shank.

The wrenches are in three sizes and take the following ranges for flanges either standard, machined or extra heavy.

No. 1. 2½ inch to 4 inch.
No. 2. 3½ inch to 6 inch.
No. 3. 6 inch to 12 inch.

ROSSITER S. SCOTT, M. E.,
Consolidated Gas Electric Light & Power Co. of Baltimore, Md.

Ill. Nos. 24, 25, 26 and 27.

DESIGN FOR C. I. PIPE FOR CEMENT JOINTS.

ROSSITER S. SCOTT, M.E.,
Baltimore, Md.

Ill. Nos. 28 and 29.

A WATER SEAL VALVE

Quick Opening.

Quick Closing.

Economical:—No mechanism to get out of order.

Sure:—An absolute stop for Gas.

You Know Where You Stand:—(Because you can practically see the interior working of your valve).

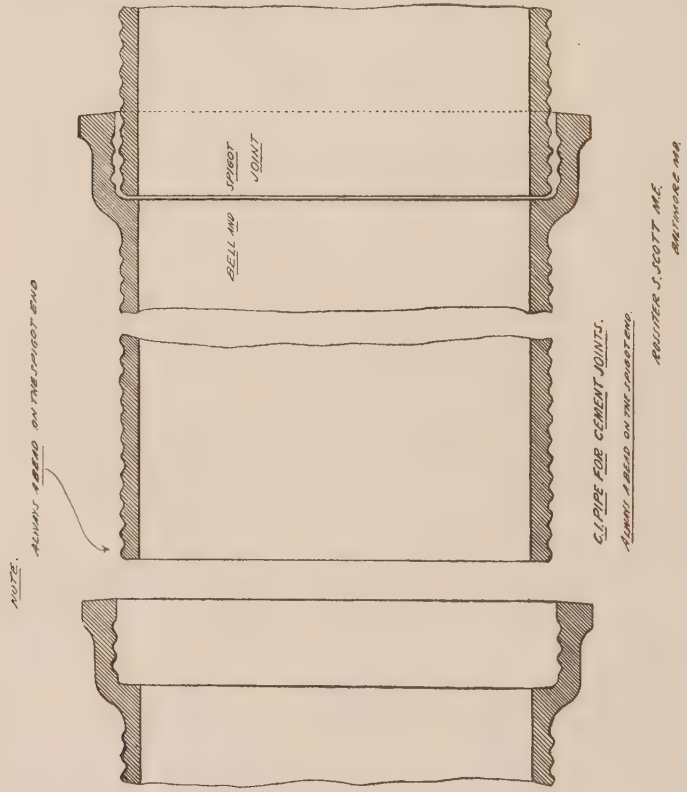
Acts as Catch Basin to carry off Waste Products:—Flushes itself. Always clean.

Automatically Relcases Excess Pressure on Apparatus, the depth of seal however being set to suit conditions.

A Small By-Pass enables the line to be purged without disturbing the water seal, and also the pressure may be equalized on each side of baffle plate while putting the valve in service.

Locates Immediately Any Trouble or stoppage that may occur in the piping system—*Its a veritable "Tattle Tale."*

The Water Gauges besides showing the pressure in the line on each side of valve also show just how much seal is carried



Ill. No. 28.

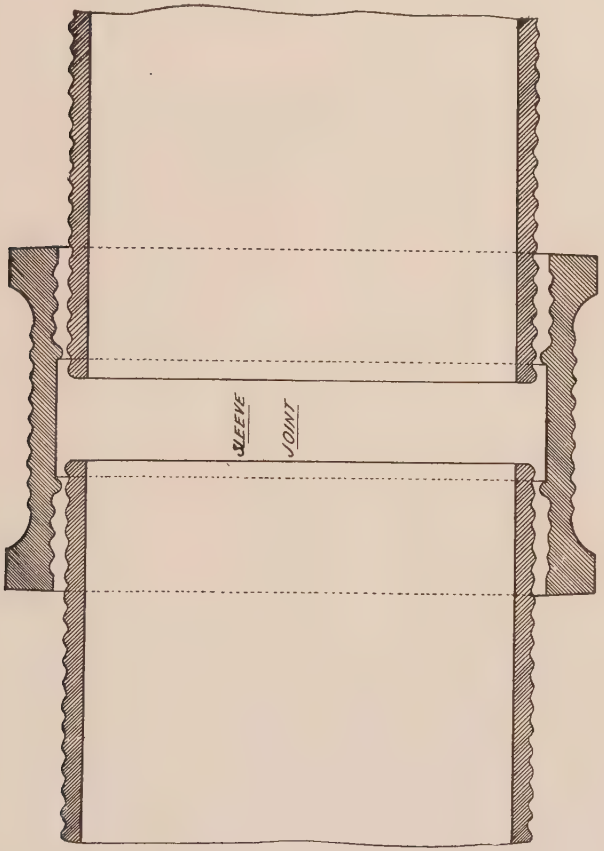
so that an *onlooker* may be sure at any time that this valve has effectually stopped the passage of the gas.

This valve is especially adapted *for purifying houses and for by-pass to meters* and other gas apparatus.

The valve being *a Water Seal Valve* an automatic release is thus provided in case of any excess pressure, the depth of seal however being set to suit conditions. It is particularly suitable for a By-pass valve.

By means of the water gauges any trouble may be located immediately.

Stock Valves in four (4) *Sizes*—For either 30 in. 24 in.



Ill. No. 29.

20 in. or 16 in. size pipe with depth of seal to suit conditions, *it is not advisable to use this valve underground* as the expense is too great for the necessary excavating, etc.

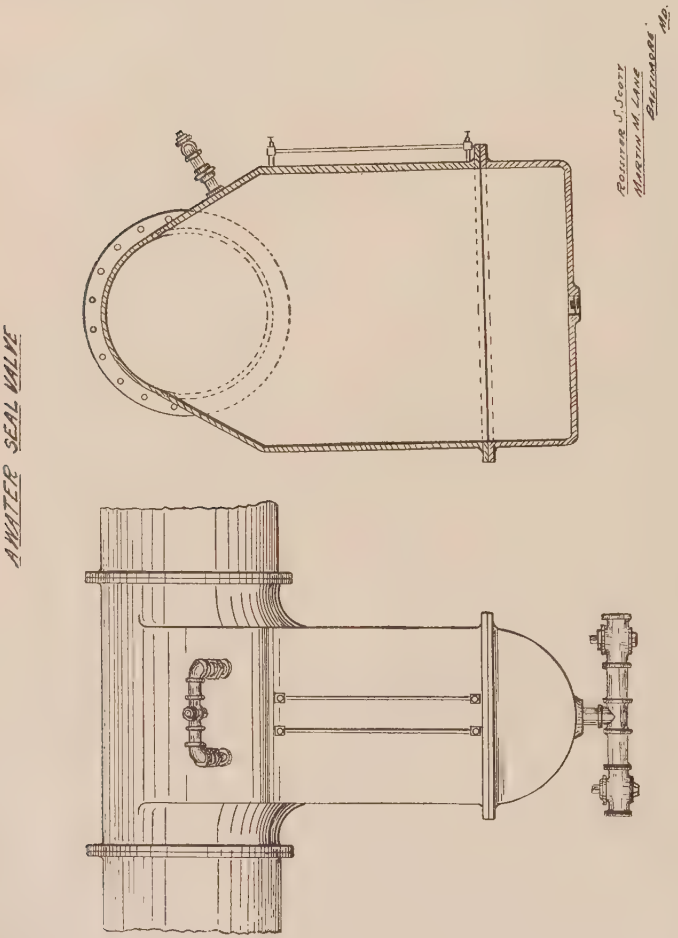
Patent applied for.

Rossiter S. Scott, M. E.,
Consolidated Gas Electric Light & Power Co. of Baltimore, Md.

Ill. Nos. 30 and 31.

USE OF OLD OIL BARRELS.

In laying pipe under rivers and other water channels old oil



Ill. No. 30.

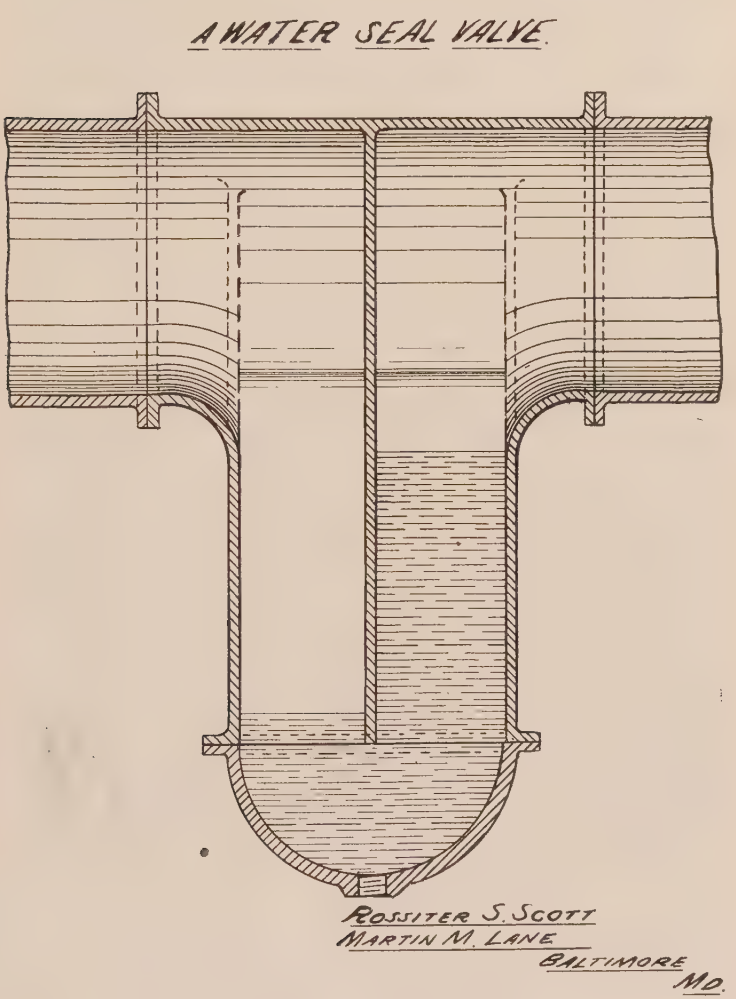
barrels can be used to advantage for floating pipe into place before lowering as shown by enclosed photograph. These barrels have a buoyancy of about 400 lbs. each.

G. T. MACBETH,
Mt. Vernon, N. Y.

Ill. No. 32.

COPPER GUARD FOR OIL METER.

The drawing shows copper guard placed around oil meter.



Ill. No. 31.

This guard prevents oil which might break through the

Ill. No. 32.

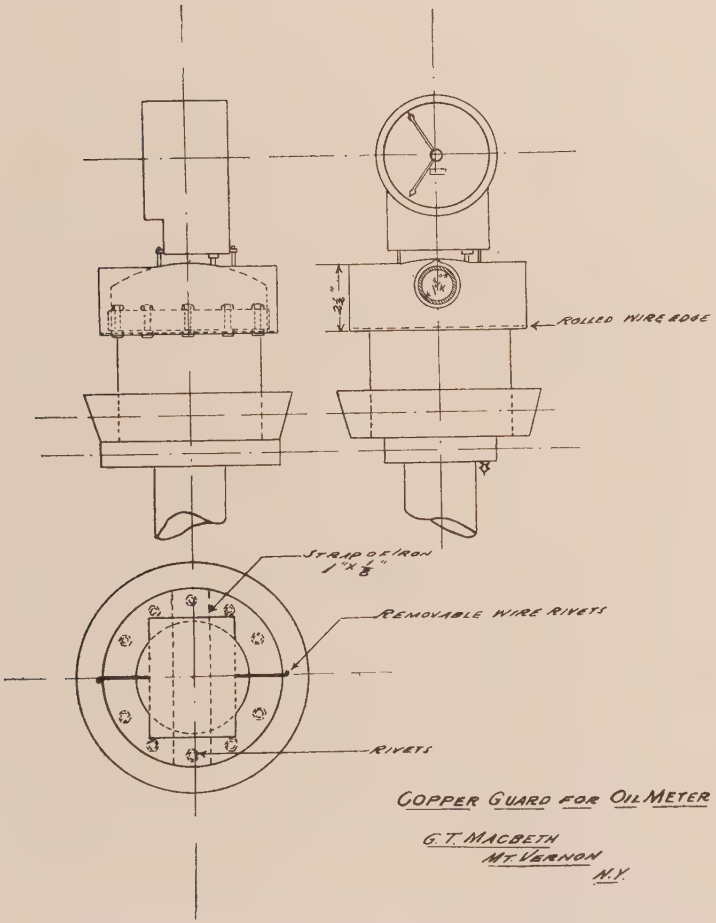
gasket from reaching any flame which might be in the vicinity of the meter.

G. T. Macbeth,
Mt. Vernon, N. Y.

Ill. No. 33.

SETTING OF GAS RANGES.

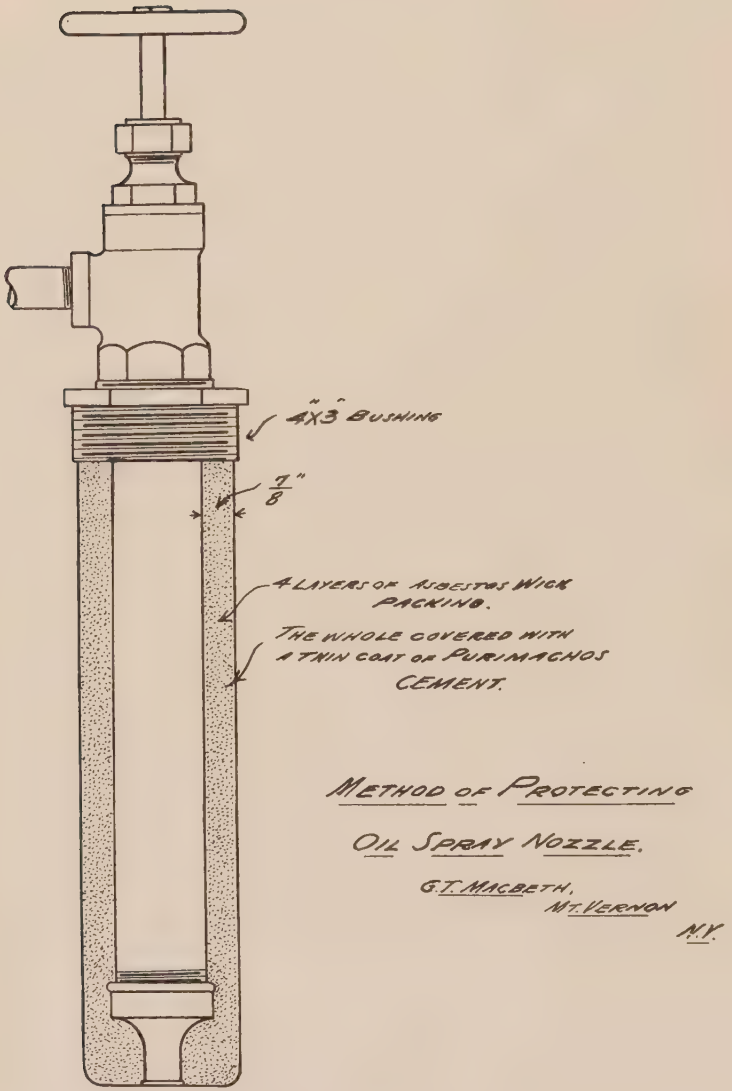
Setting Gas Range cost can be greatly cut, if architects are



Ill. No. 33.

visited and gotten to specify that buildings are to be equipped with separate range line from front of cellar to kitchen. We have had no difficulty in getting architects to do this.

G. T. Macbeth,
Mt. Vernon, N. Y.


4"x3" Bushing
7/8"
4 Layers of Asbestos Wick Packing.
The whole covered with a thin coat of Purimachos Cement.
Method of Protecting Oil Spray Nozzle.
G.T. Macbeth, Mt. Vernon N.Y.

Ill. No. 34.

METHOD OF PROTECTING OIL SPRAY NOZZLE.

Extra wrapping on Oil Sprays and same covered with

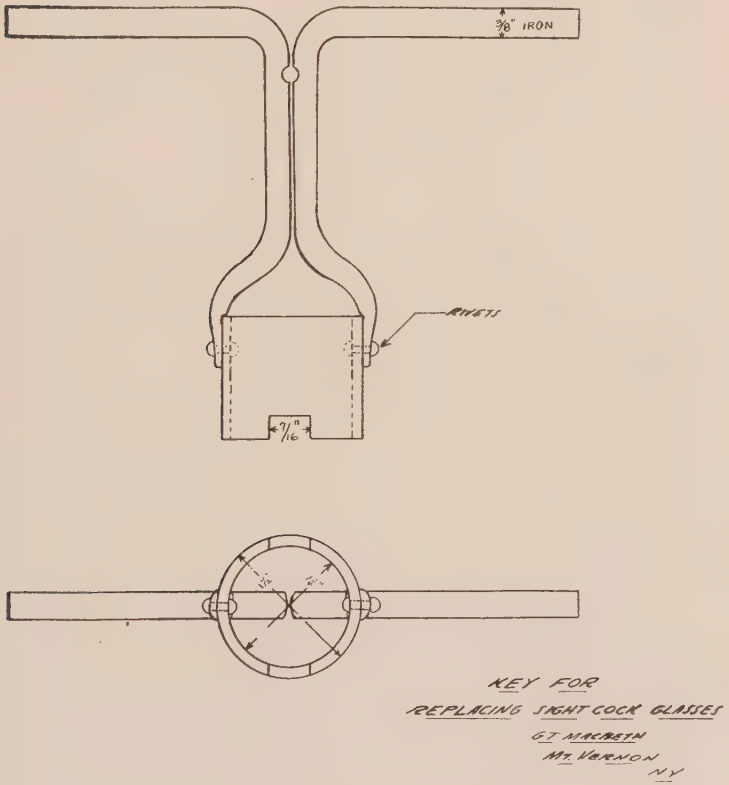
cement as shown by enclosed sketch lengthens the age of them materially.

G. T. MACBETH,
Mt. Vernon, N. Y.

Ill. No. 34.

KEY FOR REPLACING SIGHT COCK GLASSES.

The key or wrench shown in cut is very handy in renew-



Ill. No. 35.

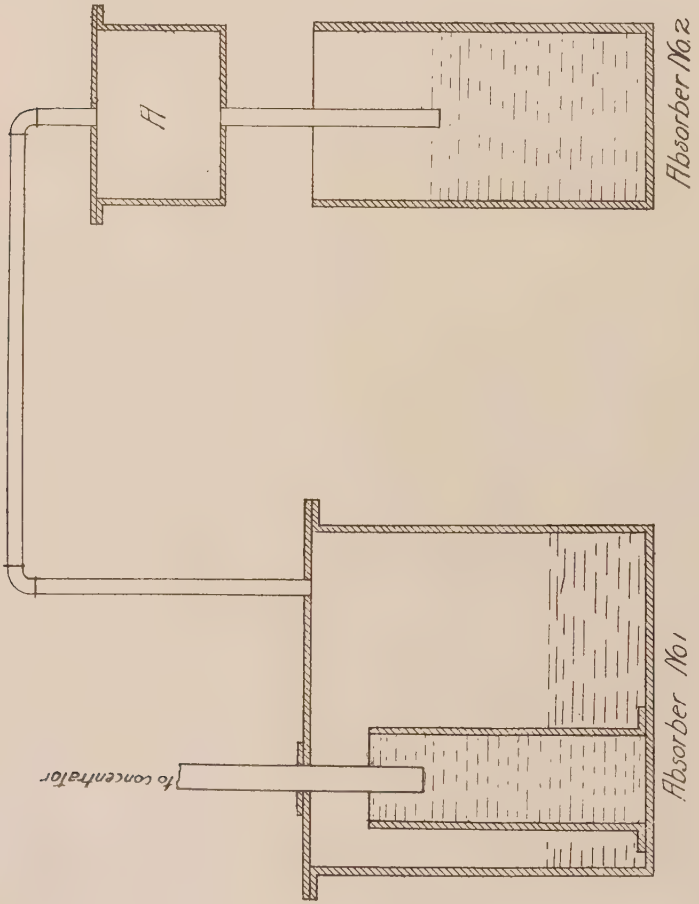
ing broken glasses of Sight Cocks.

G. T. MACBETH,
Mt. Vernon, N. Y.

Ill. No. 35.

A DEVICE TO PREVENT SYPHONING IN THE AMMONIA APPARATUS.

To prevent the weak liquor in absorber No. 2 from being



Ill. No. 36.

syphoned into absorber No. 1, place small tank A in line connecting absorbers. Capacity of tank A should be about ten times the amount of liquor forming seal in absorber No. 2. When a vacuum is created in absorber No. 1, seal in No.

2 is sucked into tank A, and when pressure is again formed in absorber No. 1, liquor is forced back into absorber No. 2.

A. W. YOUNG, Superintendent,
The Knoxville Gas Company, Knoxville, Ten.

Ill. No. 36.

A TIME SAVER

Ill. No. 37.

The following is a description of the method used in the

Meter Repair Shop of the Mohawk Gas Co., of Schenectady, N. Y., for oiling meters and making them dipping. The photograph shows a table covered with galvanized sheet iron on which the meters rest while being oiled. Above this is suspended a smooth board 2 in. × 4 in., with 1½ in. holes bored in it 8½ in. apart, centre to centre. This is supported by ¼ in. rope attached to a cross piece, and running through pulleys above, the rope having a ring at the end to adjust it to the proper height by means of a series of nails driven in the table support. The funnels shown inserted in these holes are ordinary 1 quart funnels reduced to a spout, to which is attached a flexible steel drop light tubing 1 ft. long, and having a nozzle on the end to insert in meter when oiling. A small hook is soldered near the end of this so that the tubing may be hooked up when not in use, preventing the dripping of the oil which clings to the side of the funnel when empty.

The photograph shows 10 meters in position, five of which are being oiled. The tubing has not been inserted in the other five as yet, and is shown hooked to the board as described above.

This represents a fair sized outfit, and as indicated, has 10 funnels, one for each meter, and the best results are obtained by oiling one side of each meter all the way down the line. When the funnels are empty shift the tubes to the other side of the meters, and repeat the operation.

It is important that no tubing be inserted in more than one meter at a time, so as to be sure to avoid any skipping. When rubber tubes are used they should be allowed to hang toward a drain when not in use, as the oil will soon spoil the rubber. However, steel drop tubing is the best thing to use for this purpose.

L. MATTHEWMAN.

Ill. No. 37.

SERVICE AUGER.

For many years it was the custom of the Atlanta Gas Light Company to take up cement pavements when laying services.

Ill. No. 38.

The accompanying illustration shows a very simple and home-made device for boring a hole under the pavement, and which has saved us large sums of money.

The drill is turned by an ordinary ratchet and the long shank works on a pivot inserted in the upright bar.

A. H. WIMBERLY, Foreman of Shop,
Ill. No. 38. Atlanta Gas Light Company.

METER SETTERS AS INSPECTORS.

I submit the following, which is original with me and which I am sure is not in practice elsewhere. This method is giving fine results here.

First, the regular fitters do not set meters. They merely run range lines and connect ranges and water heaters.

The meters are set by the meter setters, who also put gas on the range lines, regulate the ranges, and inspect the work.

If there is a leak it is up to the inspector to locate and repair it, also to report same. This not only insures inspection of all appliances but insures perfect meter connections, as half of the imperfect meter connections are caused by fitters not having the proper length nipples on the job and rather than return to the shop for nipples of proper length, they will leave the work connected with nipples which are too long or too short, and, although the meter will hang plumb, there will be a strain on the meter tubes that is bound to cause trouble in a short time, as has been proven here. The meter repair men reported forty-two (42) meters changed during the month of April, with broken tubes, and up to the present time (two months) there have only been three (3) meters which have had to be changed, that were set since I have had the meters set by the inspectors. The inspectors' wagon will carry a large assortment of nipples, ranging from close nipples to nipples 12 in. long, and it is possible to make up a perfect set of meter connections under almost any conditions.

Of course, this does not mean that the foreman need not make any inspections, as it is really important that he should make as many as possible, in order to know for himself just how things are going, but by having someone covering all the jobs there is no chance of anyone getting poor service.

This method of inspection also gives the foreman a better chance to get on the various jobs while the men are doing the work, and he is able to explain to the men any difficult part of the work on the job, and show them just how the work should be done under certain conditions. He can show them how to do the work neatly and quickly. The foreman is really a teacher, and as such he should always be on the job to educate his fitters. A great many very good men have not been able to make good just because they were not properly coached, but turned over to careless fitters.

Therefore, in a small city of from 50,000 to 150,000 population, where an inspector is a large extra expense to a fitting department, the above method of furnishing inspectors is very economical.

A. J. LeTarte,
Mohawk Gas Company, Schenectady, N. Y.

COMPRESSED AIR FOR METER TESTING.

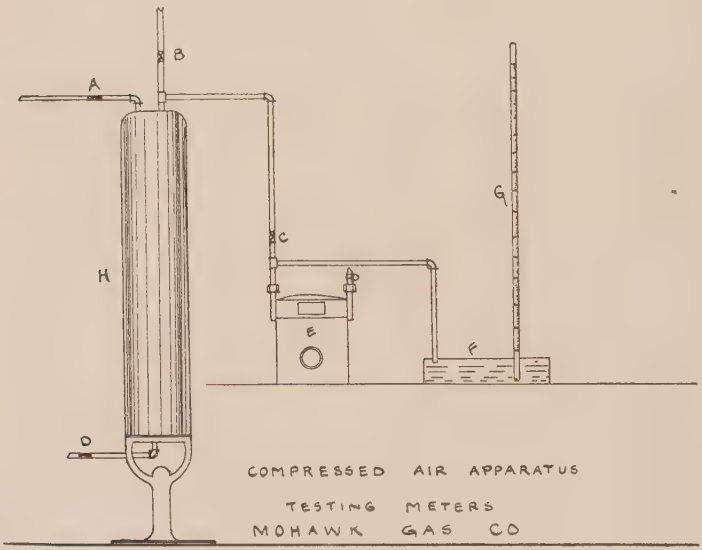
The Mohawk Gas Company of Schenectady, N. Y. found that under the new system of dipping meters small oil leaks would develop which could not be discovered under ordinary gas pressure. To overcome this difficulty it was decided to use an air pressure, not over 2 lbs. The compressed air for this purpose was obtained in the following manner:—

Referring to the sketch:—"H" represents an ordinary 30 gallon tank which is connected up with the city water supply, the pressure of which is approximately 80 lbs. The operation is as follows:—

The vent cock "B" and drain cock "D" are opened, allowing the water to escape from the tank, and the tank to fill with air, then cocks "B," "C" and "D" are closed, and "A" opened, turning on the city water pressure. This water is allowed to flow until the back pressure from the compressed air is sufficient to stop further amount of water from coming into the tank. Stock cock "A" is then closed and we have a small

volume of air, but under a high pressure. This air is used in the following manner:—

Meter "E" is connected as shown, but preferably with a flexible hose connection so as to permit the turning of the meter on end, and stop cock "C" is slightly opened, allowing the pressure that is desired to accumulate in the meter, and which can be read on the water gauge. Ordinarily when 1½ lb. is reached stop cock "C" is closed, and the outlet of



Ill. No. 39.

the meter having been closed, if the meter is tight the water column "G" will retain its height, any leak, of course, being evidenced by the fall in the head of water. To discover such a leak a very small luminous gas torch is passed over all seams of the meter, and any leak will be shown up by a slight blowing on this sensitive flame.

This apparatus is very simple to connect and easy to operate, as one charge of air is sufficient to test 50 meters ordinarily.

Precaution must be taken, however, to see that all joints are absolutely tight, and this is best accomplished by using shellac instead of white lead on the threads.

Ill. No. 39. V. von Starzenski.

TOOLS FOR CAULKING INSIDE OF LATERAL BELLS OR OPENINGS ON SPLITTERS AND CROSSES ON HIGH-PRESSURE MAINS

With special caulking tools designed in accordance with the drawing attached hereto, and with the aid of a tapping machine for high-pressure mains (such as the one described in "Wrinkles" on pages 738-9-10 of the Proceedings of the Institute for 1909), split tees and crosses can be installed on and lateral connections made to high-pressure mains while the mains are under pressure.

After the split tee or cross has been bolted on pipe and leaded, the joints on the inside of lateral bell opening are caulked from the inside, making a perfectly tight joint, rendering the caulking of the end joints unnecessary. The main is then tapped for the required size lateral pipe.

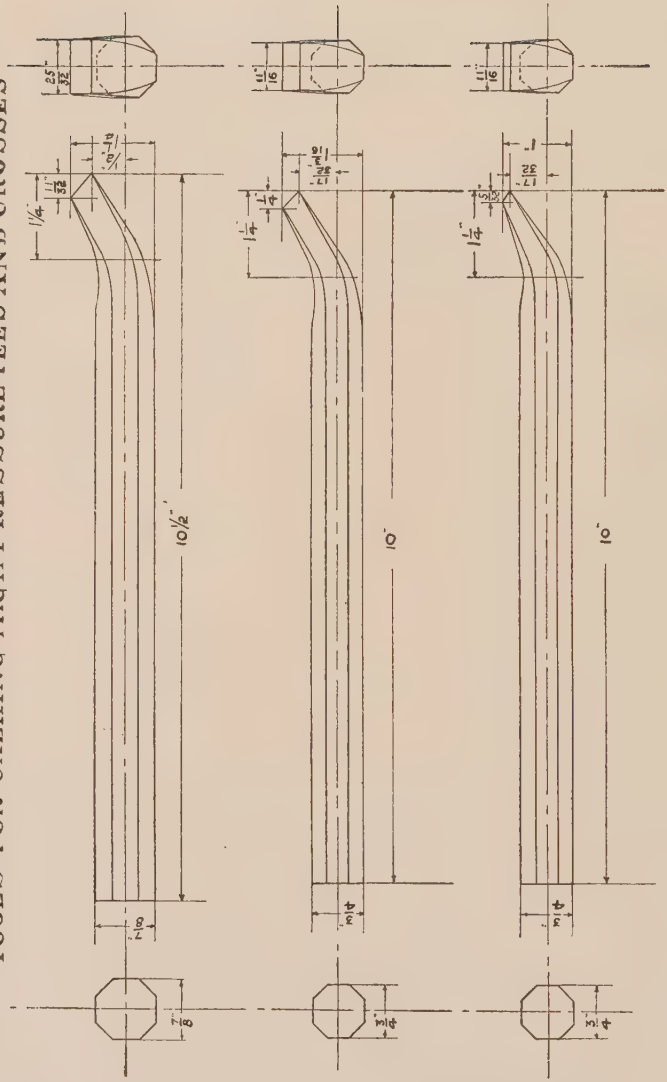
W. J. Dorr, Superintendent Gas Distribution,

Ill. No. 40. Los Angeles Gas and Electric Corporation.

A DEVICE USED FOR LEVELING.

While located at Lancaster, Pa., I had occasion to level up the station meter, across the front face and from the front to the back face. There were a number of obstructions on the meter and an ordinary spirit level could not be used, and being in a closed building, it was impossible to make use of an engineer's level. I obtained a long piece of rubber tubing, and in each end inserted a piece of glass tubing, filled the tube with water and was thus enabled to obtain a level plane, which was indicated by the height of the water shown in the glass tube on each end. By placing these tubes against the planes to be leveled, I was enabled to do the required leveling work.

TOOLS FOR CALKING HIGH PRESSURE TEES AND CROSSES



Ill. No. 40.

Such a device would have many special uses in leveling.

F. C. FREEMAN,
United Gas Improvement Co., Philadelphia, Pa.

BEER PUMP FOR FURNISHING COMPRESSED AIR IN METER SHOP.

In large meter shops the testing of gas meters for leaks before placing them on the proving table is made with compressed air at about one pound pressure.

Ill. No. 41.

Many small shops have always employed a prover-like tank of about five cubic feet capacity, filled with gas and weighted to obtain the pressure required, a less desirable but usually more convenient method than providing compressed air.

A very handy method of providing compressed air for this purpose is to utilize a standard "Beer Pump," consisting of a thirty gallon steel tank, 48 in. × 18 in., on the top of which is mounted a double action pump with hand wheel and pressure gauge.

Air is compressed at the rate of two pounds per minute when pump is operated. Two to ten pounds pressure is worked

up in the tank. The outlet connection of the meter to be tested must be securely capped, and air turned on slowly until the pressure required is shown on a permanent thirty inch water gauge placed between the valve or cock on tank outlet and the meter inlet, and then turned off. If the meter and connections thereto are tight there will be no loss in the height of the water column. A loss in the height of the water column will indicate a leak, which can be readily located by the application of a tiny pilot search light which will be quickly extinguished by the escaping air when the leak is found. This method will be found quick and convenient and all danger of explosion is obviated.

Wm. J. Welsh, Vice-President,

New York & Richmond Gas Co. Stapleton, New York City.

Ill. No. 41.

METHOD OF REPAIRING STANDPIPES.

Occasionally a standpipe may become broken from unequal expansion or other causes, and as a general rule, the first thing thought of is to replace the broken one with a new one. The following repairs have been used quite satisfactorily:—

For 7 in. standpipe use an 8 in. wrought iron nipple 12 in. long, as follows: Remove the bridge pipe and raise standpipe high enough to allow 8 in. nipple to slip 6 in. over the broken end next to the mouth piece. A couple of small iron wedges drawn very thin may be driven between the nipple and standpipe to prevent slipping. Next lower upper section of standpipe into the top of the 8 in. nipple. You will find the nipple fits very nicely and requires but a slight grouting of patching cement to make a tight joint. The tar and carbon deposit will shortly fill up around the union and make a permanent and inexpensive repair.

S. E. D. Frese, Superintendent of Manufacture,

Chattanooga Gas Company.

BRISTOL GAUGE USED FOR WATCHMAN'S CLOCK.

Mr. Dexter writes, "We have no white night foreman and it occurred to us that a watchman's clock would be desirable to keep tab on the night negroes. We have a Bristol gauge in our exhauster room, and I simply put an independent cock on the gas supply and made the night negro open and shut this quickly every hour. Of course, the opening in the independent cock has to be throttled so as not to make too big a mark. This scheme serves as a watchman's recording clock, and also makes the man keep his eye on the pressure at regular intervals."

MacDougald Dexter,
Gas Light Company of Columbus.

NEW BUSINESS WRINKLE.

There are various wrinkles or methods used to increase the consumption of gas, and one that we have found to be valuable is as follows:—

We start by making a systematic house to house canvas, getting all the data and information possible. Upon returning to the office at night, the slips are sorted under the following heads:—

1st Water Heater Letters.
2d Range Letters.
3d Connect Letters.

A list of the names and addresses is then made and letters mailed to the housewives covering their individual needs.

These letters are mailed the same day the canvas is made. Two days later they are followed by a personal call, which has secured business for us in most cases.

While making this canvas from house to house, all vacant places are tagged with a "vacant house tag." These cards are five inches square, of thick red cardboard and the reading in black. These tags are hung on the front door, and in cases where the meters are being disconnected in the house or store,

the tag is hung in a prominent place, preferably on the lighting fixture in the front hall. The card reads as follows:—

Front Side: Stop and read, when ready for gas and electricity to be connected phone 2720, our representative will call and take care of your wants.

Reverse side, Montgomery Light and Water Power Company, Dexter Avenue, Montgomery, Alabama.

This system of "business getting" is showing results and is bound to succeed. Personal cards are used and left at each call. A card which has brought in results is as follows:—

Front side,

G. T. Coggswell,
District Manager Phone 2720
M. L. & W. P. Co.
See other side

Reverse side,

Three Important Questions

1. Have you a gas range?
2. Have you a water heater?
3. Are these appliances in condition for immediate use? If not, phone me.

G. T. Coggswell, District Manager,
Montgomery Light & Water Power Co.

METER TICKET FOR REPORTING APPLIANCES, ETC.

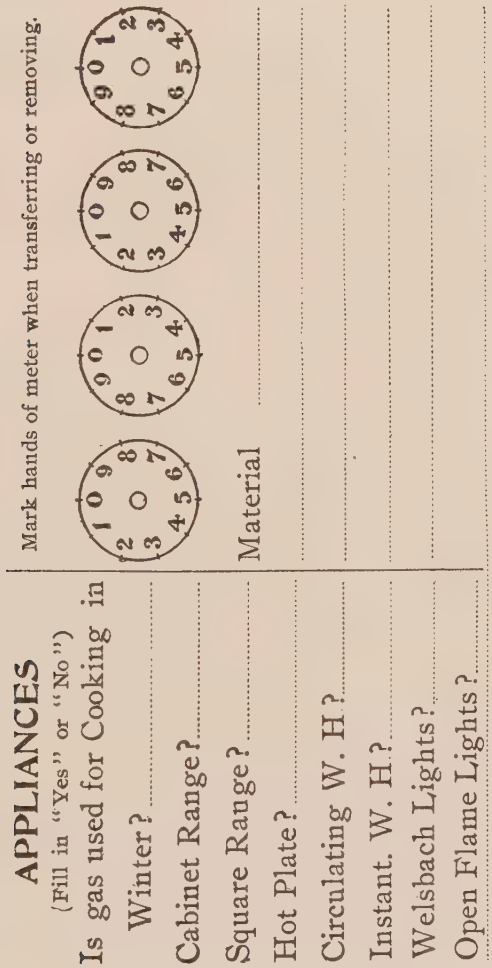
Mr. E. C. Burton, General Superintendent, Philadelphia Surburban Gas and Electric Company, writes, "I find that the provision recently made on our meter tickets for reporting the appliances in use at the time the meter is set very satisfactory and advantageous; likewise, marking the hands on the meter dials as also provided on our meter tickets enables us to settle many disputes with customers as to the final reading on their bills.

E. C. Burton, General Superintendent,
Philadelphia Surburban Gas and Electric Company.

Ill. No. 42.

WHISTLE ALARM FOR RELIEF HOLDER.

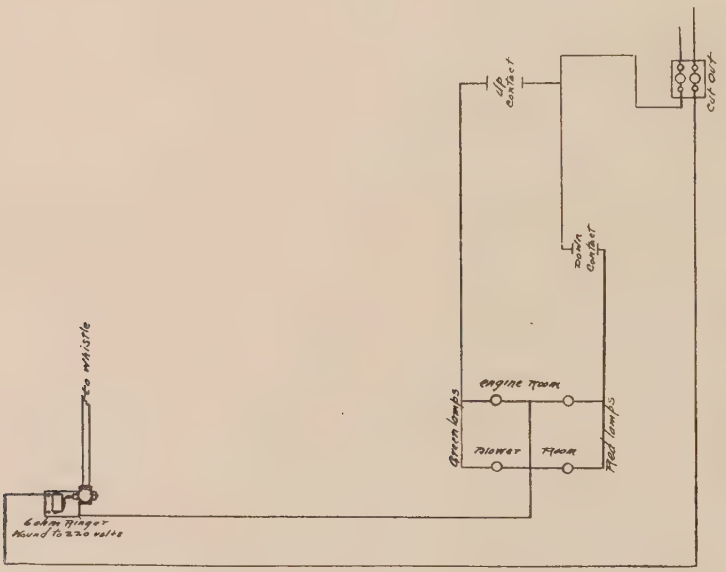
The contrivances ordinarily employed for relief holder protection generally depend upon dry, or wet cells for their



Ill. No. 42.

operation. The great objection to such schemes is the unreliability of the cells. We have overcome this by having made up special, powerful ringers with their magnets wound

to 220 volts, and have connected them to our electric power circuit. The gongs of the ringers have been dismounted and the hammers made to act directly upon a whistle valve. The accompanying sketch shows a ringer connected in series with electric signal lamps of different colors to our relief holder. The contacts are so arranged that whistle blows and lamps



Ill. No. 43.

are lighted when holder is two sheets from blowing, and grounding stages. At blowing point green lamps light, and at grounding point the red lamps. Whistle blowing at the same time notifies the engineer, who then starts or stops exhauster, but whistle does not stop blowing until circuit is broken. A high power whistle is used, that can be heard above any of the loud noises about the works.

Indianapolis Gas Company, Indianapolis, Ind.

Ill. No. 43.

OXIDE MIXER.

For sometime we had mixed our oxide by hand, which was not only costly but very slow.

Ill. No. 44.

Recently we obtained a concrete mixer which was very easily converted into a satisfactory oxide mixer. The shavings, iron filings and lime are fed by a belt into a mixing

drum, which is turned by a small gasoline engine. This drum is inclined so that the mixture will gradually work to the lower end. About three feet from the lower end a pipe delivers the copperas water. The oxide is delivered out of the drum thoroughly mixed and in excellent condition. The shavings are not badly broken up and the oxide is better than when mixed by hand. The discharge from the drum is continuous and, therefore, a small machine has a very large capacity. The amount of shavings, lime and iron borings is adjusted by changing the sizes of the outlets of the bins which hold these materials.

The accompanying picture shows this machine in operation.

The cost of mixing is about 25 per cent. of the cost of doing the same work by hand."

D. J. Young, Sup't Gas Manufacture,
Los Angeles Gas & Electric Corporation.

Ill. No. 44.

SOME ROCHESTER FEATURES.

Air Compression.

1. In Gas Fitting shop we use a 200 gallon storage tank connected with a compressor driven with a motor with rheostat adjusted so as to carry a uniform air pressure of 200 lbs. This air is used for cleaning out services and house piping as follows:—a 40 gallon tank is carried in the wagon and filled with air from the large storage tank. We take a small five gallon tank also; fill the smaller tank from the tank in the wagon, disconnect the meter and connect the small tank to the riser or service, turn on the air and one charge cleans out the stoppage. By this means the same man can do three times the amount of work and a great deal easier than the old style pumps. When blowing out riser be sure to disconnect some side bracket on top floor. The air in this tank is taken from the meter shop so that we use this air pressure for raising the bells in our meter provers, which makes it much easier

and faster for the man who is testing meters. The air in this case is carried at only 2 lbs.

Delivering Gas-fittings.

2. For delivering fittings for house piping, water heaters and stove connections, we use boxes of the following measurements: 10 × 10¼ × 4⅞ in. deep inside measurements, painted in different colors. For instance, the house piping boxes are painted green, stoves red and hot water heaters blue. Nailed to the cover on the inside of the box is a blue print describing the kind and amount of fittings which are necessary for an 8 in. opening job of house piping. In the stove connection, box the necessary fittings to do an average stove connection and the same in regard to the hot water heater box. These boxes are delivered, stocked with these fittings, to the various jobs where work is to be done. The fitter, when the job is finished, fills in a blank form with the number and kind of fittings which he has used, so that when the box is returned to the storehouse, the storekeeper takes the slip and refills the box with the fittings which are noted on the slip which are marked as having been used, thus leaving the boxes all ready for next delivery. This saves the picking up of scattered fittings left in consumers' cellars; saves sorting them out in the storeroom into bundles; saves the fittings from being stolen, in fact saves us $7.50 per day.

Shop Tools.

3. The tools which are used in the shop are all painted red, making them easily detected if stolen by employees. We keep duplicate stocks and dies of all sizes at the bench, which saves a great deal of labor in not having to change die and guides.

Cutting Nipples.

4. At one of our water power stations, two men are always kept in reserve in case of accident. They have very little work to do, except watch the station and keep things clean and oil the machinery. In this station we have a pipe threading

machine and these men cut all the nipples used by the Company, make up radiators which are used on furnace connections, cut threads on the large sized pipes. This is practically clear gain to us as we have to have these men on duty.

Pipe and Meter Benches.

5. The benches in our shop are covered with boiler iron, in our Meter Department with ⅛ in. iron, and in our Gas Fitting Department with ¼ in. iron, making a very smooth surface which can be used for pounding out and straightening out any light metal without going to an anvil, and for various other purposes; and prolongs the life of the bench indefinitely. When first placed our men did not like it, but after getting used to it they are very much pleased, and prefer it to the wooden top.

Polishing Gas Stoves.

6. For polishing old stoves we use power,—that is, electric motor with revolving brushes. This work can be done by one man where it formerly took four, and can be done much better.

Electric Fans in Barn.

In our barn, in which there are 50 horses, it has always been impossible for the horses to lie down and sleep for any length of time on account of the flies. We have placed electric fans pending from the ceiling behind these horses, and these are used continually in hot weather, which keeps the flies out of the barn. The horses are not bothered with flies now and get the rest and sleep which nature demands, and it is surprising how they have improved in looks and weight.

Crushed Oats.

8. We have installed a Gibson Feed Crusher for crushing oats, and the oats which are now used are crushed so that we figure we save two quarts of oats per day per horse, and all the horses are doing a great deal better on this crushed feed. At the start some of the horses did not like the feed, but they

quickly got used to the feed, and prefer the crushed oats to the uncrushed.

Working on Live Gas.

9. In the last four years we have not had one case of asphyxiation or gas explosion for the reason that we do not allow one man to work alone on live gas. All our men who have occasion to work on live gas (except gas street work) 'phone to the shop where we always have a man with motor-cycle in reserve whom we send out to help make these connections. By having this extra man in the shop we save an extra man on the meter wagon, and also an extra man in the connecting of our gas ranges, and still avoid all accidents.

FRANK HELLEN, Supt. Gas Distribution,
Rochester Railway and Light Co., Rochester, N. Y.

DESIGN OF BRIDGE PIPE AND MOUTH PIECE.

Bridge pipe A is the same design as is generally used, with the exception of the end receiving standpipe. This is Spigot instead of the customary Flange. This removes the expansion joint where the carbon deposit is less, and also takes care of the longitudinal expansion of Retorts, a point well worth considering.

It is my opinion that the Flange joint on Bridge Pipe receiving the standpipe is entirely too rigid, and frequently, if not generally, responsible for unlevel mains, due to strains received from expansion of both retort and standpipes.

Cast Iron Hood B, instead of having stud bolts to support mouthpiece, has recesses into which bolts may be dropped from the outside, as shown in figure D. Mouthpiece C has slots instead of bolt-holes.

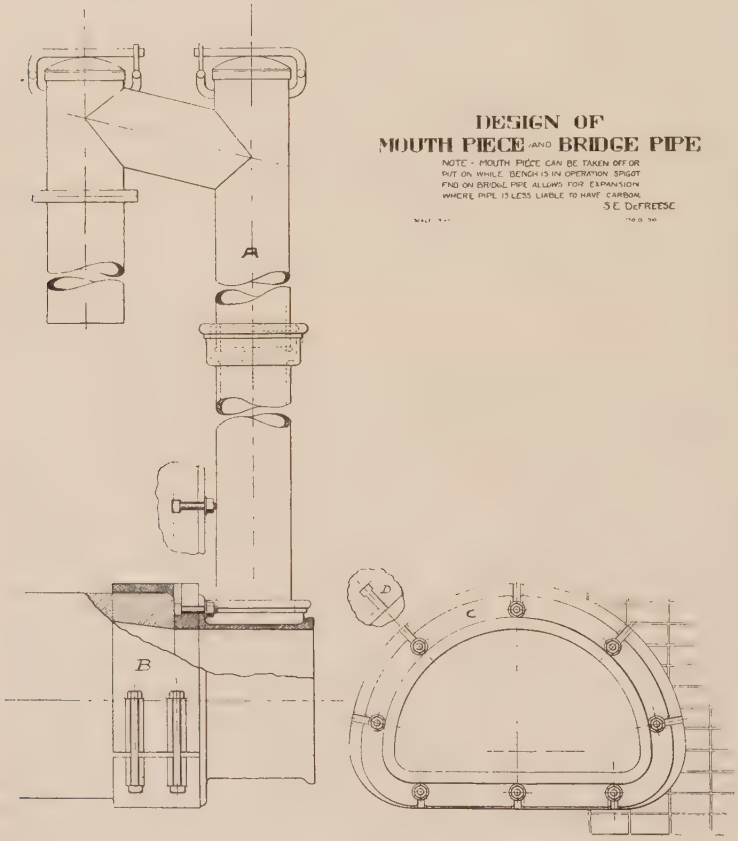
The advantages claimed for this design are that you can much more easily replace the mouthpiece while bench is under fire, and it completely eliminates the trouble of mouthpieces dropping off, due to broken studs, etc.

S. E. DE FRESE,
Chattanooga, Tenn.

Ill. No. 45.

DEVICE FOR HOLDING UP THE STACK VALVE LEVER

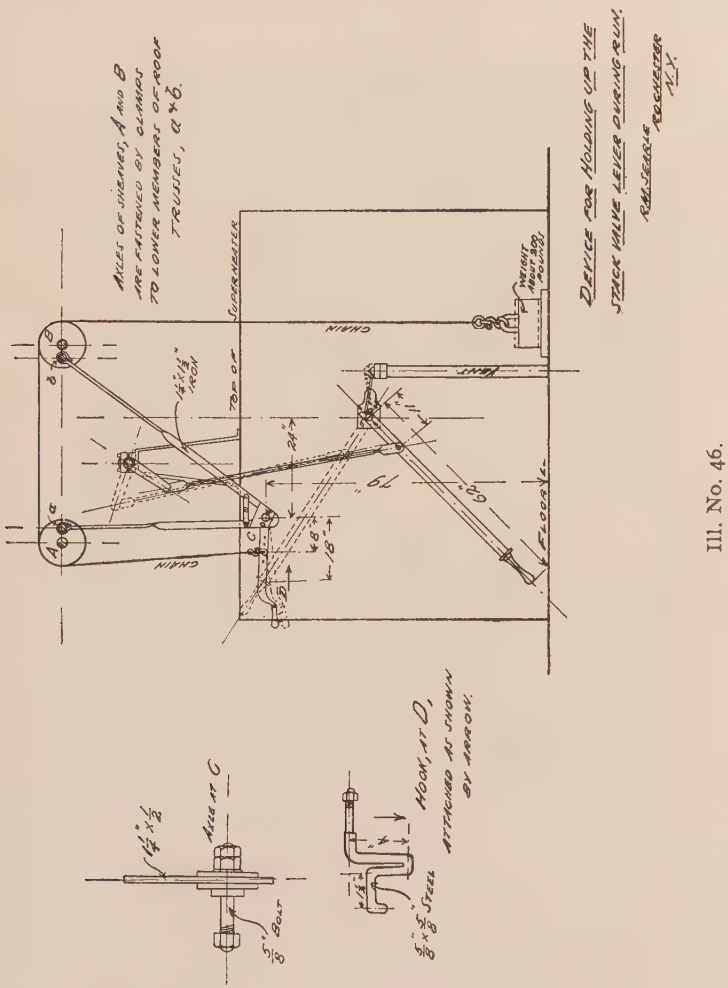
At the Westchester Lighting Company's Yonkers Works the connections are small which makes it necessary to hold the Stack Valve down against high back pressure. It was


DESIGN OF
MOUTH PIECE AND BRIDGE PIPE
NOTE - MOUTH PIECE CAN BE TAKEN OFF OR
PUT ON WHILE BENCH IS IN OPERATION. SPIGOT
END ON BRIDGE PIPE ALLOWS FOR EXPANSION
WHERE PIPE IS LESS LIABLE TO HAVE CARBON.
S.E. DeFREESE
A
B
C
D

Ill. No. 45.

our custom to put a strip of wood against the stack valve handle and wedge the stack valve lever tight. This did not allow the stack valve to act as a safety valve as designed. A counter weight, counter lever and pulleys were made to hold the stack

valve handle up and act as a safety valve if necessary, and


Device for holding up the stack valve lever during run.
R. M. Searle
Rochester N.Y.
Axles of sheaves, A and B are fastened by clamps to lower members of roof trusses, 6 x 6.
Screenhouse
Weight about 300 lbs.
Chain
Top of
Floor
Axle at C
Hook at D, attached as shown by arrow.

Ill. No. 46.

allow man to handle additional weight without much physical effort.

R. M. Searle,
Rochester, N. Y.

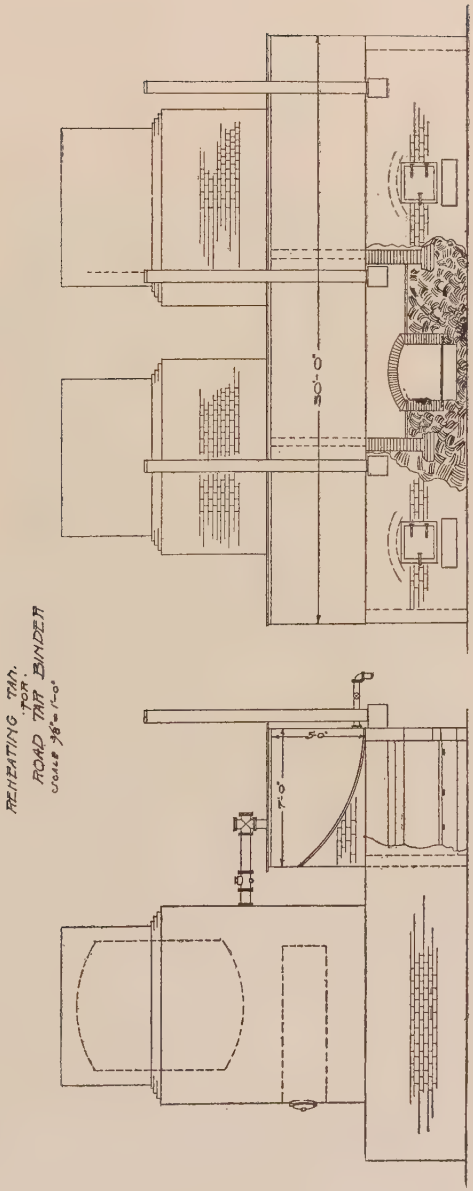
Ill. No. 46.

REHEATING TANK FOR ROAD TAR AND PITCH.

The object of this tank is to permit the contents of a tar

Ill. No. 47.

still to be drawn off when the proper temperature or consistency has been reached in the still and to provide a tempo-



Ill. No. 48.

rary receptacle in which the pitch or road tar may be heated up again to the proper temperature for loading into barrels or tank wagons.

The tank also acts as a smothering chamber, confining the heavy fumes that arise when drawing off pitch. Our tank as

Ill. No. 49.

constructed is 30 feet long and is divided into three compartments, allowing separate storage of pitch and road tar. Under each compartment there is a fire-box. A fire-brick arch shields the bottom of the tank, the products of combustion

escaping at the rear end of the arch into a space under the tank and finally escaping through a stack.

ALAN D. WHITTAKER, Supt. of Works,
Atlanta Gas Light Company, Atlanta, Ga.

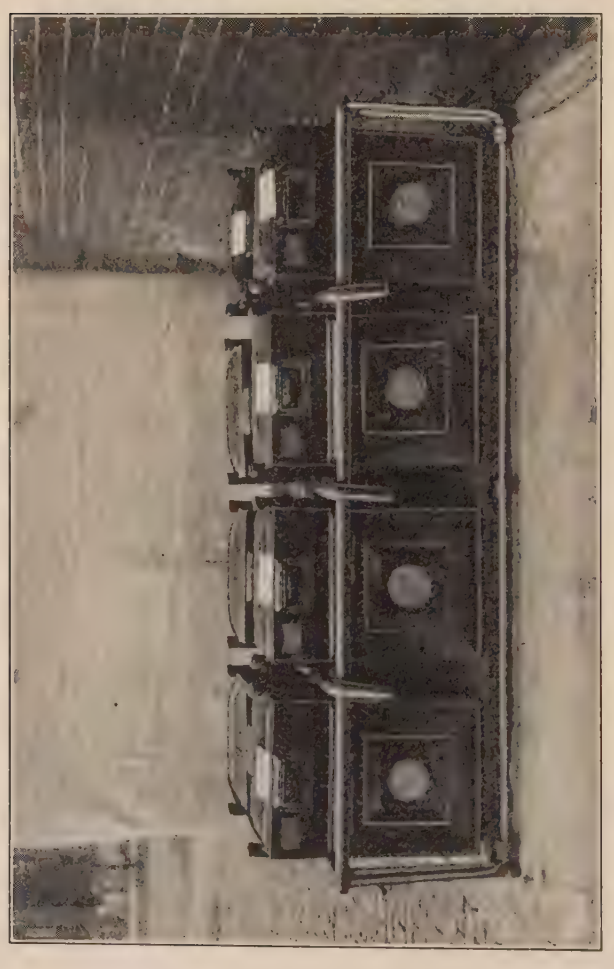
Ill. Nos. 47 and 48.

Ill. No. 47.

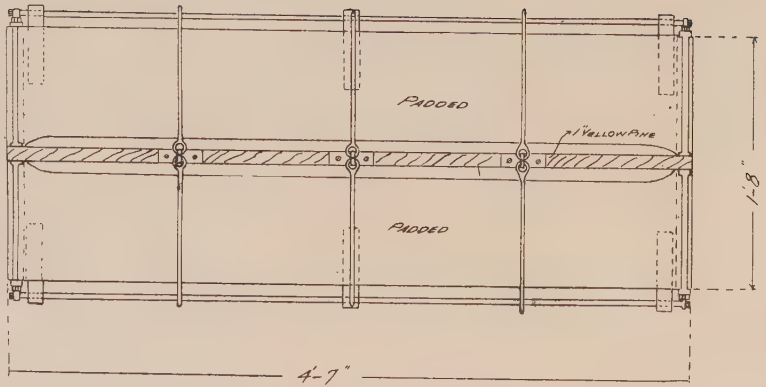
METER RACK FOR METER WAGONS

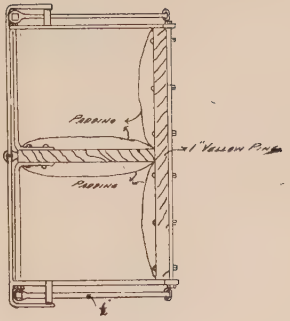
Laclede Gas Light, Co.,
St. Louis, Mo.

Ill. Nos. 49, 50, 51 and 52.

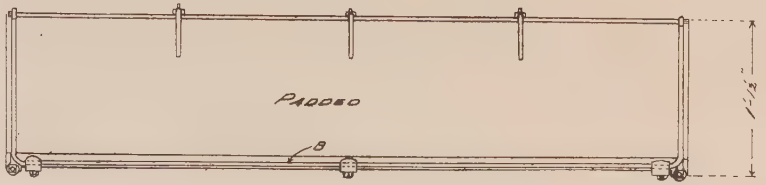


Ill. No. 51.





NOTE:
ALL RODS TO BE COVERED WITH ¾" RUBBER HOSE EXCEPT B.
ALL RODS TO BE ⅝".



METER RACK FOR METER WAGONS.

THE LACLEDE GAS LIGHT CO.
ST. LOUIS
MO.

Ill. No. 52.

FASTENING LUGS TO PREPAYMENT METERS.

In certain types of prepayment meters, it has been found that the lugs or staples when attached with square head bolts can be much more conveniently removed for replacement than when attached with the round head bolts that were used for this purpose.

JAMES MATLACK, Meter Department,
Consolidated Gas Company of N.Y.

ADJUSTABLE LIP FOR PREPAYMENT METERS.

In certain makes of prepayment meters, the greatest number of breakages are found where the lip is placed, or where the lock and box are connected. By making this lip adjustable, the expense of repairing all meters broken in this way is very materially lessened.

JAMES MATLACK, Meter Department,
Consolidated Gas Company of N.Y.

FOR CIRCLE BENDS.

Circle Bends can be cut and used, as shown by attached table, to good advantage in place of 22½° and 45° bends, for making off-sets. Spigot piece of the bends that are left over can be used economically by purchasing 22½° and 45° 2-bell bends which can also be used to advantage going around manholes and other obstructions in streets. .

G. T. MACBETH,
Mt. Vernon, N. Y.

Ill. No. 53.

CONNECTION OF GAS WATER HEATER TO HOUSE BOILER.

Greater efficiency can be gotten from Gas Water Heaters

if outlet of heater has a separate spud connection near top of

For Circle Bends
60° Bends,

a = r sin α
b = r - r cos α
c = r versin α
A = 2a
B = 2b + throat.

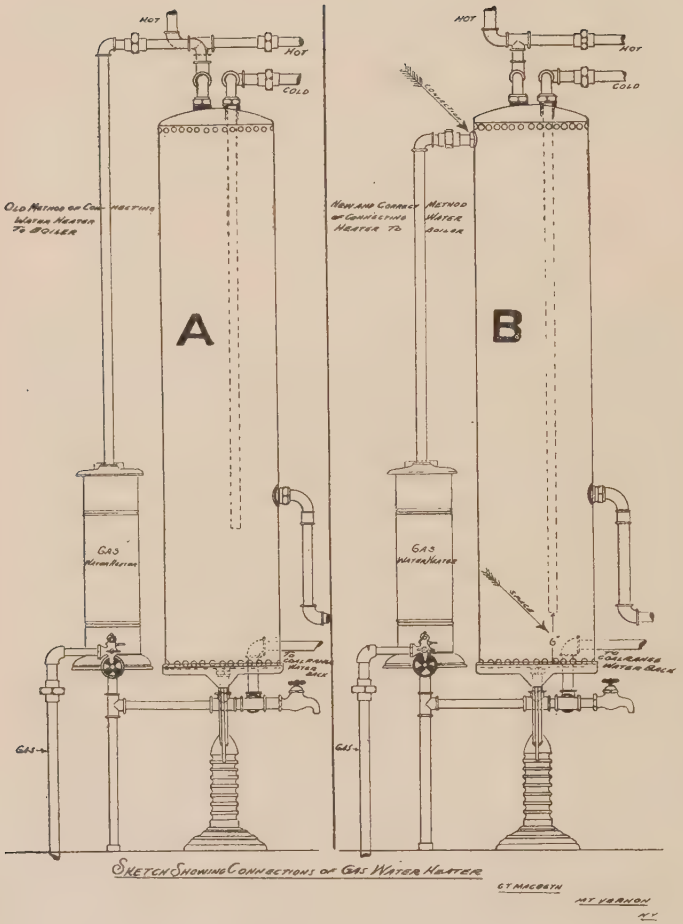
NOTE:
1" in length of arc of circle bend of 60° radius equals nearly 1°

G. T. MARCELETH
MT. VERNON
N.Y.

Arc.	a	b	c	α	Arc.	a	b	c	α
12"	11 45/64"	1 1/8"	6"	11° 28'	38"	35 3/4"	11 5/8"	19 1/2"	36° 17'
13"	12 1/8"	1 1/8"	6 1/2"	12° 25'	39"	36 1/4"	12 1/4"	20 3/8"	37° 15'
14"	13 1/8"	1 1/8"	7"	13° 22'	40"	37 1/2"	12 7/8"	20 3/4"	38° 12'
15"	14 3/8"	1 1/4"	7 1/2"	14° 20'	41"	37 7/8"	13 1/2"	21 5/8"	39° 10'
16"	15 5/8"	2 1/16"	8"	15° 17'	42"	38 3/16"	14 1/8"	21 7/8"	40° 7'
17"	16 3/4"	2 3/16"	8 1/2"	16° 14'	43"	39 1/4"	14 3/8"	22 1/2"	41° 4'
18"	17 7/8"	2 5/16"	9 1/16"	17° 11'	44"	39 7/8"	15 1/16"	23"	42° 1'
19"	18 5/8"	3"	9 5/8"	18° 8'	45"	40 3/4"	16 1/8"	23 5/8"	42° 59'
20"	19 5/8"	3 3/8"	10"	19° 6'	46"	41 5/8"	17 1/4"	24 5/16"	43° 56'
21"	20 5/8"	3 3/4"	10 1/4"	20° 3'	47"	42 5/8"	18 1/8"	24 7/8"	44° 53'
22"	21 7/8"	4 1/8"	11 1/16"	21° 0'	48"	43 7/16"	18 7/16"	25 3/8"	45° 50'
23"	22 1/8"	4 1/2"	11 5/8"	21° 58'	49"	43 7/8"	19 1/4"	25 7/8"	46° 48'
24"	23 3/8"	4 3/4"	12 3/8"	22° 55'	50"	44 3/4"	19 7/8"	26 3/4"	47° 45'
25"	24 1/4"	5 1/16"	12 11/16"	23° 52'	51"	45 5/8"	20 3/8"	27 5/8"	48° 42'
26"	25 1/8"	5 5/8"	13 1/2"	24° 49'	52"	46 3/8"	21"	27 7/8"	49° 39'
27"	26"	6 1/16"	13 3/4"	25° 47'	53"	46 1/4"	21 3/8"	28 1/4"	50° 37'
28"	26 7/8"	6 3/8"	14 1/4"	26° 44'	54"	46 7/8"	22 1/4"	28 3/8"	51° 34'
29"	27 7/16"	6 5/8"	14 3/4"	27° 41'	55"	47 3/8"	23 1/4"	29 5/8"	52° 32'
30"	28 3/4"	7 1/8"	15 5/16"	28° 38'	56"	48 1/16"	24"	29 7/8"	53° 29'
31"	29 5/8"	7 5/16"	15 3/4"	29° 36'	57"	48 1/2"	24 3/8"	30 3/8"	54° 26'
32"	30 5/8"	8 1/4"	16 1/4"	30° 33'	58"	49 1/4"	25 1/8"	31 1/4"	55° 23'
33"	31 1/4"	8 7/16"	16 1/2"	31° 30'	59"	49 7/8"	26 1/8"	32"	56° 21'
34"	32 3/8"	9 1/8"	17 3/4"	32° 28'	60"	50 3/8"	27 1/16"	32 3/4"	57° 18'
35"	33"	9 5/8"	18 1/8"	33° 25'	61"	51"	28 1/16"	33 5/8"	58° 15'
36"	33 3/4"	10 1/4"	18 5/8"	34° 23'	62"	51 5/8"	29 1/4"	34 1/8"	59° 12'
37"	34 5/8"	11 1/16"	19 1/8"	35° 20'	63"	52 1/2"	30 1/8"	34 3/4"	60° 10'

Ill. No. 53.

boiler, in place of being connected into outlet line of same.



Ill. No. 54.

Fig. A—Shows old connection.
Fig. B—Shows new connection.

G. T. MACBETH,
Mt. Vernon, N. Y.

Ill. No. 54.

DIRECT FLAME FIRING KILN.

The Laclede Gas Light Company, Saint Louis, Missouri, recently designed and installed for the Century Ornamental Glass Company, of that city a large direct flame firing kiln for the burning of stained ornamental glass. This furnace is unique in that it employs no muffle, renders an even and very high temperature and permits the firing of larger individual pieces of glass than has heretofore been accomplished either in this country or abroad. The quality of the finished product is pronounced by experts to be exceptionally high in character.

The kiln is constructed of brick, with fire-brick facing on the interior portion exposed to the heat. The ceiling is sufficiently arched to be self-supporting, is equipped with three vents to allow escapement of the products of combustion and its highest interior point is about nine inches above the burner line. The interior dimensions are, length, six feet; depth, 38 inches; height, 51 inches to the highest part of the ceiling. Fifteen horizontal burners, 50 feet per hour capacity each, and equally spaced, are placed horizontally on each side and extending through the walls so the flames form a horizontal plane about one and one-half inches above the glass. A specially constructed iron tray, supported by a steel track is provided to carry the glass into and out of the furnace. The consumption of gas is governed by requirements, varying from 800 cubic feet per hour when operating normally to 1,200 cubic feet when higher temperatures are wanted. 2,100 F° has been attained without difficulty.

J. J. Burns, Supt. New Business Dept,
The Laclede Gas Light Company, St. Louis, Mo.

BURNER FOR HAT MANUFACTURERS.

One of the serious difficulties heretofore experienced by hat manufacturers has been the presence of soot from the illuminating flame in burning gas to heat the molds. This has been overcome by the Laclede Gas Light Company by design-

ing a frog shaped burner, with atmospheric air mixer so made as to be adjusted to any sized mold for either upper or lower portion. The results produced by an installation made for one of the large manufacturers in St. Louis have been excellent. The burner produces the characteristic blue flame, eliminates all soot, and reduces the loss, due to the destruction or injury of goods.

J. J. Burns, Supt. New Business Dept,
The Laclede Gas Light Company, St. Louis, Mo.

A VENTILATED GAS FIXTURE.

The idea is to have a space of about one inch between the

Ill. No. 55.

8 inch and 16 inch reflectors which connects with a 2 by 3

galvanized iron conduit inside of the wooden box shown above fixture. This conduit in turn connects with the chimney. The ceiling of our new office building is covered by hollow wooden boxes which are intended to represent girders, there being a light at each intersection.

By means of these fixtures, the products of combustion, as well as the dead air in the office, will be carried up through the chimney. Also, it enables the burner to be placed very close to the ceiling.

The ignition is by means of a jump spark system and the gas is turned on and off by means of an electrically operated cock. The photograph shows an experimental burner which was put up for trial purposes.

A. R. Beal, Manager, Gas Dept.,
Newburgh Light, Heat & Power Co., Newburgh, N. Y.

Ill. No. 55.

SOME GRAND RAPID FEATURES.

1. Following up Correspondence: Carbon copies of all letters are placed temporarily in a loose sheet holder or spring back binder. This is looked over every few days and the letters which have been replied to or which do not require reply are removed from the binder and placed in the permanent files. This leaves in the binder the copies of all letters that need following up, and keeps the writer in constant touch without having to depend upon his memory.

2. Cleaning arc globes: "Bon Ami," the well known scourer, is splendid and the best thing we have ever found for cleaning arc lamp globes.

3. Testing by-passes: Much future trouble is avoided by carefully testing all by-passes for Welsbach lights before they leave the Storeroom. This is done by rigging up a pipe with a number of pillar cocks to which the by-passes are connected and permitted to burn for a short time, and are thus tested for leaks, stoppages in the pilot tubes and defective or poorly fitting regulating screws.

4. Refinishing Reflex burners: Reflex burners which have been returned after having been out on trial or otherwise used, can be taken apart and refinished by local platers, and after being properly re-assembled are as good as new. No lacquer should be used by the plater, as it turns red when the lamp is burning.

5. Meter Route Books: We have found that the most satisfactory covers or binders for loose leaf meter route slips are made of aluminum, not covered, with angle telescoping backs, one back being hinged to each cover, and having loose posts, that is posts not riveted to the back.

A. G. Schroeder,
Grand Rapids Gas Light Co., Grand Rapids, Mich.

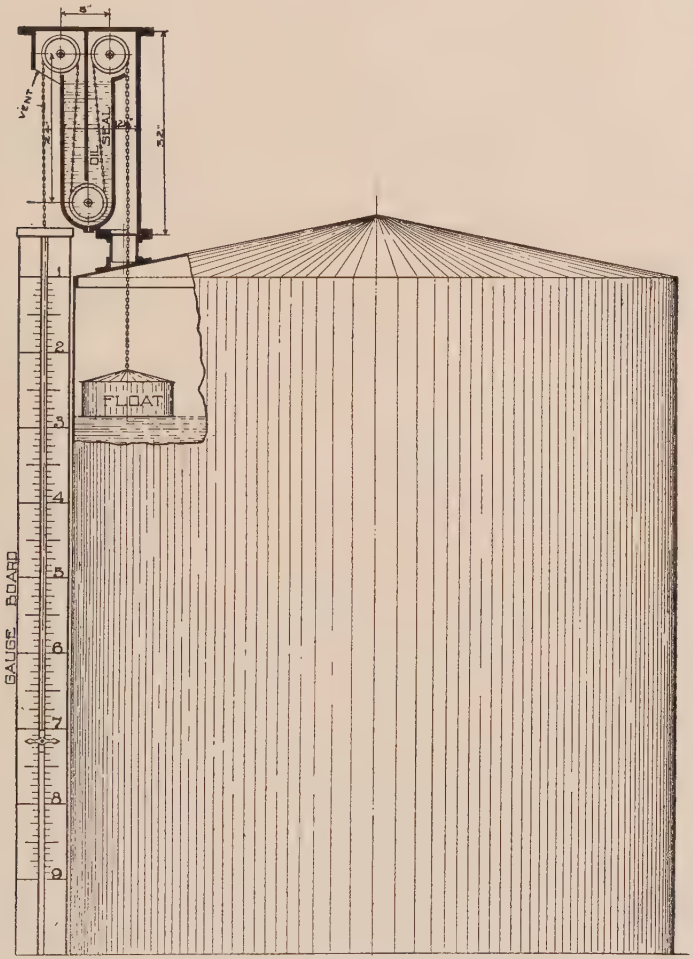
DEVICE FOR MEASURING OIL IN OVERGROUND TANKS.

The accompanying illustration shows a simple device for obtaining correct measurements of oil in an overground tank without having any unprotected openings.

It is necessary to have a vent for all oil tanks which must be covered with wire gauze to prevent any flash-backs in case of fire near the tank. It has been customary in a number of plants to have another opening similar to the vent with wire gauze over it, but with a hole through it. It is obvious that this allows an unprotected opening where the chain passed through the gauze; and this practice has been condemned by the fire inspection bureaus. To overcome this objection this apparatus was made.

As shown in the sketch, the chain passes over the pulley at the top, down through an oil seal to another pulley, and up again through another leg of the seal, and down to the measuring scale. This allows the chain to work freely through the oil and there is no unprotected opening to the oil in the main tank. Should the oil in the seal take fire, it is prevented from flashing back by the deep seal provided by the center plate. This seal will also prevent the collapsing of the tank in case the vent becomes plugged or is not large enough to

admit sufficient air when oil is being pumped out of it. The pulleys are accessible by removing the top plate and a hand



Ill. No. 56.

plate on the side of the casing concentric with the bottom pulley. A drain cock is let into the bottom of the "U" to drain off all oil, as shown on the sketch. There is also an

opening on the side of the casing for filling the seal with oil. Any non-freezing oil can be used in this seal. A cheap combination can be made for zero weather by mixing two parts of black oil to one part of kerosene.

This seal should be inspected regularly to see that it is kept full of oil.

This device was invented by Mathias Conners, Superintendent of the Pitney Court Station of the Peoples Light and Coke Company, Chicago, Illinois.

Ill. No. 56.

MELTING AND MOLDING GLUE COMPOSITION FOR PRINTERS' INKING ROLLERS BY THE USE OF GAS WATER HEATERS.

As shown in the sketch, two No. 9 Vulcan Water Heaters (A) are attached to a thirty gallon boiler (B). The hot water (C) from the boiler (B) enters the top of water-jacketed kettles (D), and after circulating around the sides passes through outlets (E) in the bottom of the kettles, and flows back to the water heaters (A), thus completing the circuit. The kettles are used as receptacles for melting a composition that is used on printers' inking rollers.

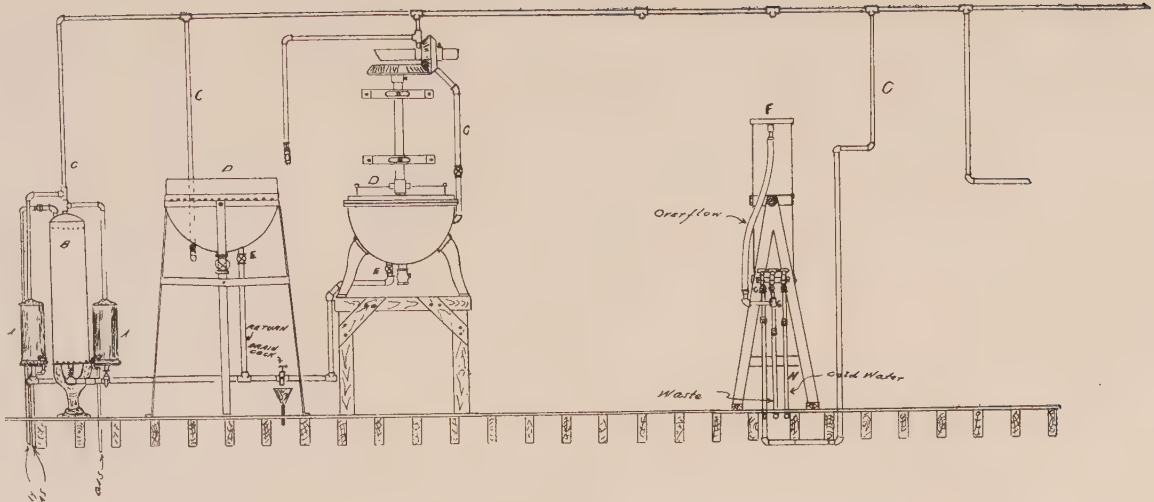
This system is then continued to water-jacketed movable molding tubes (F), in which the composition is molded into cylinders. The hot water (C) after entering the bottom of the tubes, circulates around them and passes off through an outlet (G) in the bottom. The cold water (H) is then allowed to flow into the tubes and pass off through the waste pipe (G), thus cooling the mold.

September 9th, 1910.

Ill. No. 57.

STEAMING AND PLAITING DRESS GOODS WITH STEAM GENERATED BY A GAS WATER HEATER.

The accompanying sketch shows an installation that is being used successfully by a clothing manufacturer of Baltimore, for



WATER HEATERS SUPPLYING APPARATUS IN PRINTERS
SUPPLY HOUSE

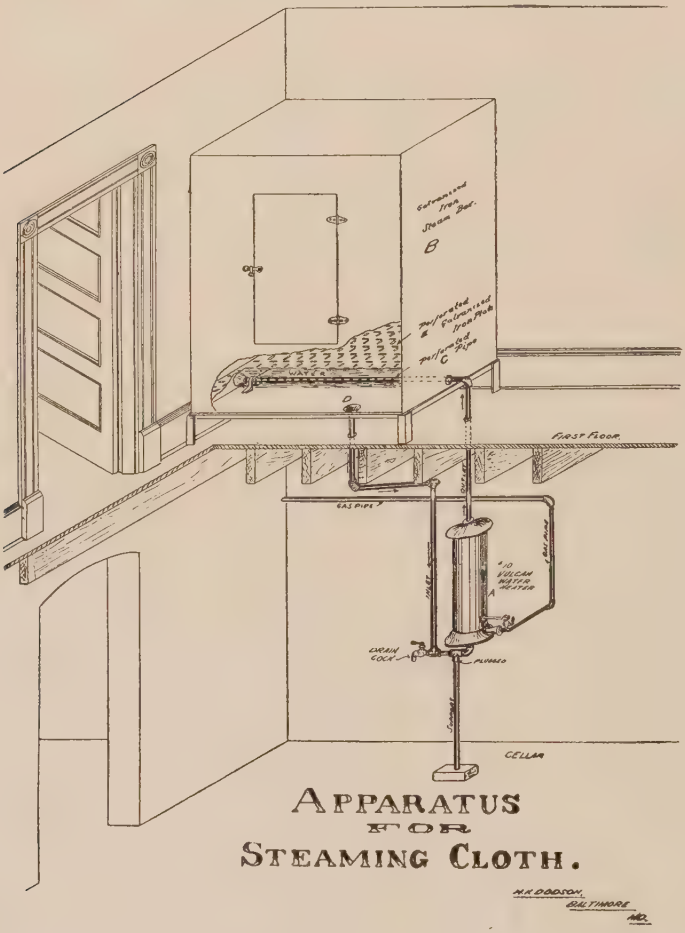
NOTE: DIAGRAMATIC ONLY

H. K. DODSON
BALTIMORE
MD

Ill. No. 57.

steaming and plaiting dress goods. It has proven entirely satisfactory and economical as well.

A No. 10 Vulcan water heater (A), placed in the cellar, is



Ill. No. 58.

connected to a large galvanized box (B) on the first floor. Water is poured into this box just below the perforated pipe (C), about four inches from the bottom, and runs to the

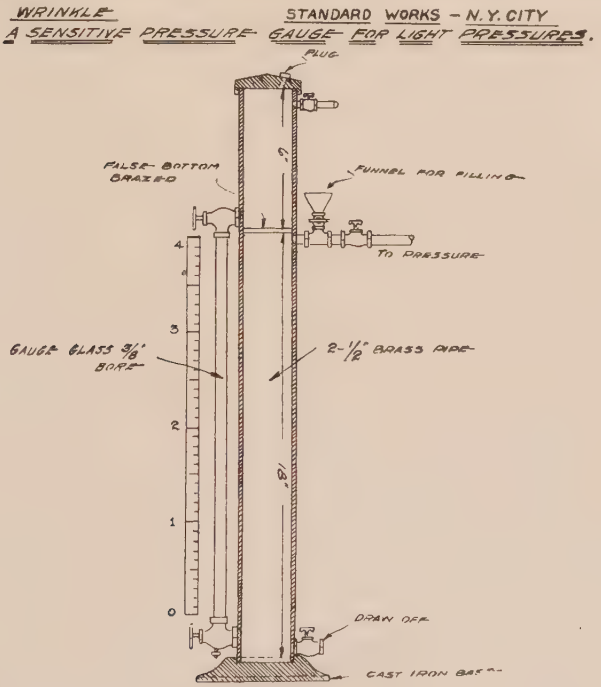
water heater through the outlet (D) in the bottom of the box. As the water is unable to circulate after it leaves the heater, steam is generated, which passes through the perforated pipe (C) running across the center of the box just above the water line. About three inches above this perforated pipe is a perforated galvanized iron plate (E) on which the goods to be steamed is placed.

September 9th, 1910.

Ill. No. 58.

A SENSITIVE GAUGE FOR LIGHT PRESSURES.

A sensitive pressure gauge for the measurement of light



Ill. No. 59.

pressures, such as pressures in consumers' mains, chimney draughts, etc., has been made in the following manner:

A piece of 2½ in. brass pipe is brazed into a cast iron base as shown on drawing and is provided with a brass cap screwed on top, also a false bottom brazed inside pipe, together with the water column cocks, gauge glass cocks, and connections shown.

The lower compartment is filled with water, colored with suitable coloring material to within, say, one inch of the false bottom, the water column cocks having been previously closed. Kerosene is then poured into the upper compartment; the upper water column cock is opened, allowing the kerosene to get into the gauge glass. Sufficient kerosene is put into the upper compartment so that when the lower water column cock is opened, the dividing line between the water and kerosene stands at zero on the graduated scale beside the glass; the top of both compartments being open to the atmosphere. The gauge is now ready to be calibrated. The upper compartment being open to the atmosphere, pressure is admitted to the lower compartment, the dividing line between water and kerosene in gauge glass will rise. The height to which this will rise for a unit pressure, depends upon the ratio between the area of the water compartment and the gauge glass, and also, on the gravity of the kerosene, and can be calculated from the formula given below. As the inside diameter of glass and brass pipe may not be uniform, it is probably better to mark the scale by testing with an arch gauge. This gauge is very sensitive, has no moving parts, and with ordinary kerosene, is found fairly constant. It can be used as a differential gauge by connecting the upper compartment to a pressure instead of being open to the atmosphere. Its chief value lies in the fact that the movement of the dividing line in gauge glass can be made any multiple of the actual pressure in inches of water. With the proportions shown on drawing, the dividing line rises approximately, 4 inches for 1 inch pressure. Any liquid lighter than water, and which will not mix with water, can be used in the upper compartment, the nearer the gravity of such liquid approaches

1 (the gravity of water) the greater will be the rise of the dividing line for a unit pressure.

FORMULA.

$$H = \frac{R}{1 + G + R(1 - G)}$$

in which H= height in inches above zero to which the dividing line will rise for one inch water column pressure.

R = ratio of areas, found by dividing area of water compartment, by area of gauge glass.

G = gravity of liquid in upper compartment (Water = 1).

The above formula is derived as follows:

The gauge must be considered as a U gauge with water in the pressure leg and say, kerosene, in the atmospheric leg. At atmospheric or zero pressure the height of the kerosene leg above the dividing line is, say, K inches and the height of the water leg is therefore KG inches.

After one inch water column pressure is applied to the water leg, the height of the kerosene leg $= K + \frac{H}{R} - H$,

the height of the water leg $= KG - \frac{H}{R} - H$.

Assuming the weight of water to be unity then:

weight of kerosene leg $= G(K + \frac{H}{R} - H)$,

weight of water leg $= KG - \frac{H}{R} - H$.

The difference between these weights is 1, for the reason that the weight of the kerosene leg balances one inch water column.

or $$G(K + \frac{H}{R} - H) - (KG - \frac{H}{R} - H) = 1,$$

or $$\frac{GH}{R} - GH + \frac{H}{R} + H = 1.$$

Solving this equation for H we have,

$$H \quad \frac{R}{1 + G + R(1 - G)}.$$

An inspection of this formula will show that by making the area of the water compartment large in proportion to that of the gauge glass or by increasing the gravity of the liquid, the value of H, or the sensitiveness of the gauge, may be increased. However, it is better to use kerosene in preference to heavier oils as it is less sluggish and keeps the glass cleaner. The contrast between the liquids may be increased by adding a little coloring matter to the water.

JAMES S. KENNEDY,
Supt. Standard Gas Light Co. Works, New York.
Ill. No. 59.

SUPPORT FOR FLEXIBLE TUBING USED IN HEATING GAS HOLDER CUPS.

Lengths of steam copper tubing of 40 to 80 ft. and over, when used for heating gas holder cups are subjected to severe strains from their weight and from being blown about by the wind.

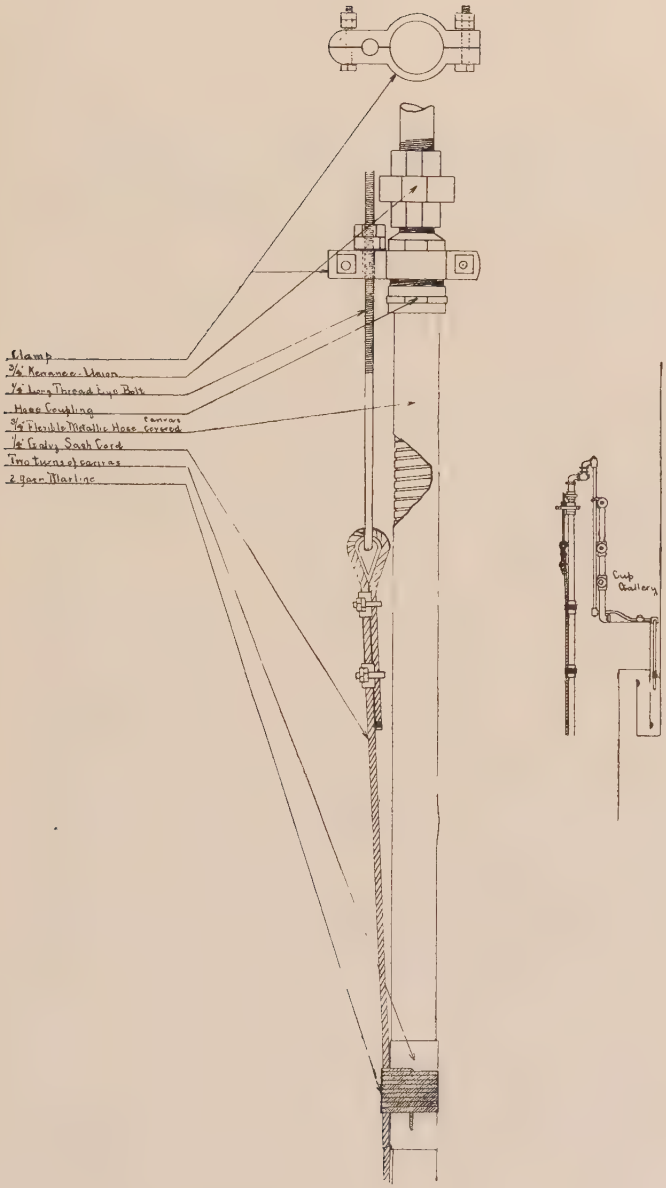
These strains cause the tubing to stretch and bind and after a time break off close to the couplings.

When the tubing is supported in the manner shown, the strains from its movement and its weight, are carried by the galvanized iron sash cord and the tubing is comparatively free to bend without binding, and in this way will be found to wear better and last longer.

When lashing the cord to the tubing—which should be done on level ground or floor—the cord should have a tension of about 100 lbs. to keep it taut; no strain should be on the tubing.

The lashings should be about two (2) feet apart.

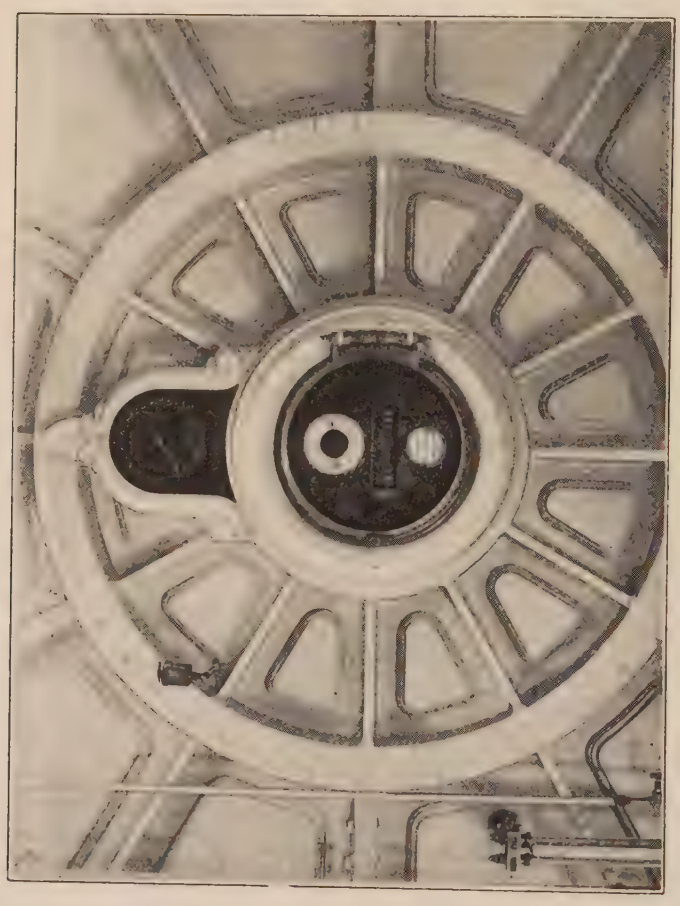
(Signed) A. RIBLET,
Supt. 14th Street Works, Consolidated Gas Co. of New York.
Ill. No. 60.


Clamp
3/8" Kenyon Union
1/2" Long Thread Lap Bolt
Hose Coupling
3/4" Flexible Metallic Hose Covered canvas
1/2" Grade Sash Cord
Two turns of canvas
2 yarn Marline
Cutt Gallery

Ill. No. 60.

TESTING AND DETERMINING LEAKS IN STATION METERS.

The accompanying photograph shows the front of a station meter at Pelham Works, provided with a test hand at-



Ill. No. 61.

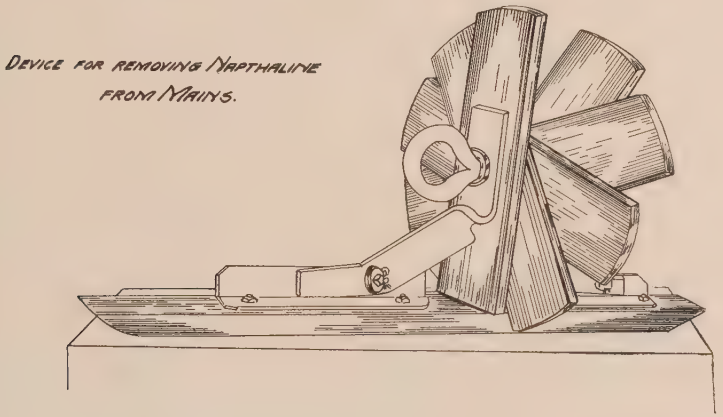
tached to the spindle of upper gear of the train, for use in testing and determining leaks in drum of meter.

GEORGE T. MACBETH,
Engineer Gas Dept., Westchester Lighting Co.,
Mount Vernon, New York.

Ill. No. 61.

DEVICE FOR REMOVING NAPHTHALENE FROM GAS MAINS.

The device is composed of a number of parts of such dimensions as will permit of their being separately entered into, and assembled together in a gas main through an aperature cut in the side. It consists of a shoe provided with angles having slotted holes to connect supports, braces, eye-bolts, shackle, nut, plates and the necessary bolts, cotter pins, etc. and can be assembled through an aperature 5½ in. by 8½ in. The disc plates may be made of steel or wood, shaped to form when assembled a full disc, but in such form with naphthalene in any considerable quantity, there would



Ill. No. 62.

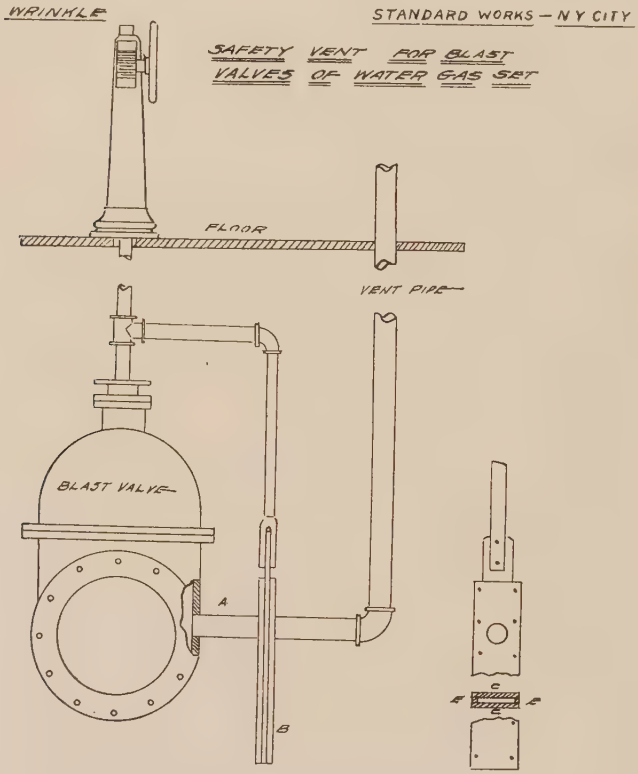
be a tendency to banking, and perhaps to the clogging of the main. The shoe holds disc in position and prevents side turning. From 150 to 200 feet of main can be cleaned at a time. After the bulk of naphthalene is removed the main can be swabbed by attaching to the eye-bolt or brace a bag filled with waste or other soft material. The manner of entering drag ropes is the same as that employed for other devices.

FREDERICK J. DOWN,
Supt. 42d Street Works, Consolidated Gas Company,
New York City.

Ill. No. 62.

SAFETY VENT FOR BLAST VALVES OF WATER GAS SET.

This is a device attached to the blast valves of a water gas set, for the purpose of preventing gas leaking into blast pipes, through leaking valves, and also, to indicate whether valves are tight or leaky. This eliminates one of the causes of blast



Ill. No. 63.

main explosions. The safety vent is illustrated in the sketch and consists of a casing (B) made in the manner shown in figures 2 and 3, by bolting flat plates (C) and strips (E) together. A slide rigidly connected with stem of blast valve works in this case, and has a port opening into vent pipe which is tapped into body of valve in space between gates.

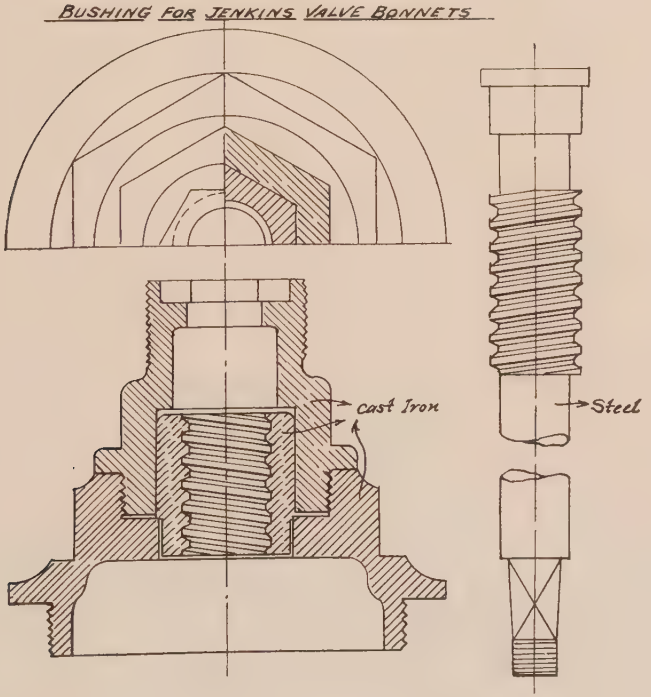
When valve is closed during a run, this slide establishes communication between vent pipe and the space between gates, allowing gas leaking through valve to get away. When valve is closed during blasting, the vent pipe is shut off. The vent pipe is carried above the floor within view of the gas-maker.

JAMES S. KENNEDY,
Supt. Standard Gas Light Co. Works, New York.

Ill. No. 63.

BUSHING FOR VALVE BONNET.

The accompanying illustration shows a cast iron bonnet



Ill. No. 64.

with renewable nut or bushing for use on valves supplying steam to water gas generators. The trouble with the ordinary valve is that the threads on the bonnet and stem soon wear

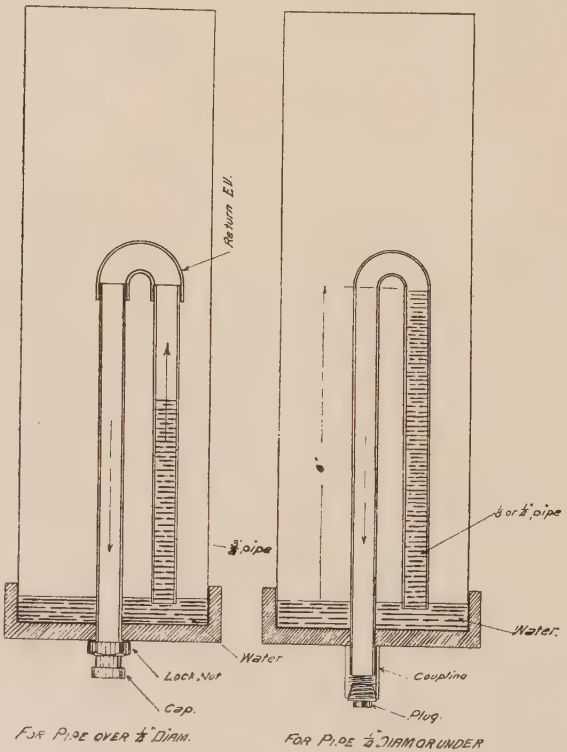
cut, and in order to make a renewal the entire bonnet and stem have to be discarded. A steel stem is used with this bushing and should last almost indefinitely while the bushing as the wearing part can be replaced for a small amount.

W. F. LAWRENCE, Gen'l Supt.,
Astoria Light, Heat & Power Co., Astoria, New York.

Ill. No. 64.

A SEALED HOUSE DRIP.

An attachment to be used in wrought iron house or inside



Ill. No. 65.

drips to prevent the escape of gas when the drip is emptied. This consists of a "U" shaped pipe, as illustrated in the sketch,

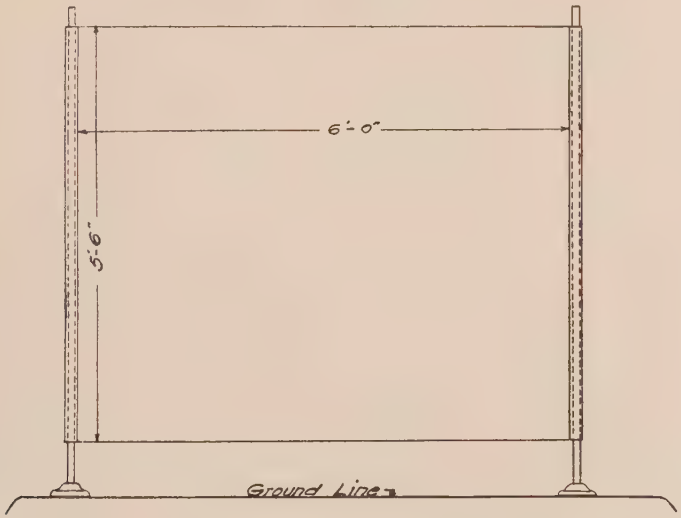
which syphons the water from the drip when the plug or cap is removed from the outlet connection.

CHARLES BARTOSCH, Street Department,
Consolidated Gas Company of N. Y.

Ill. No. 65.

A PROTECTION AGAINST FLYING CHIPS.

A canvas protecting screen to prevent chips from flying and doing injury when cutting cast iron pipe with diamond



Ill. No. 66.

point chisels. This consists of a canvas screen that can be fastened to the handles of dirt rammers and set along the trench at any point desired, as illustrated in sketch.

WILLIAM DUNNE, Street Department,
Consolidated Gas Company of N. Y.

Ill. No. 66.

ADJUSTABLE LEGS ON COOKERS.

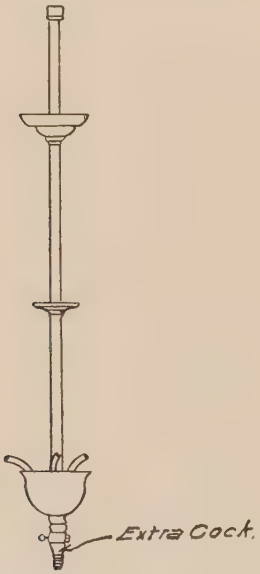
It has been found of benefit to have the legs on cookers made adjustable as this makes unnecessary the blocking up of

the cookers, in cases where the floor is not level or where two of the legs rest upon a small hearthstone or sill.

James L. Cronen, Meter Department,
Consolidated Gas Company of N. Y.

LIGHTING FIXTURE.

To put up lighting fixtures with a special hose cock, which



Ill. No. 67.

gives an outlet for a small portable or small table appliance, the sketch illustrates the method suggested.

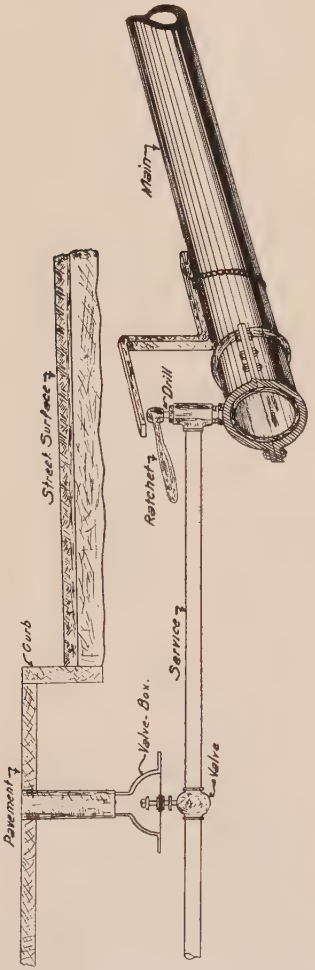
John J. Glynn, Meter Department,
New Amsterdam Gas Company.

Ill. No. 67.

MAIN TAPPING.

A method of placing split sleeve for service connection, and running the service at least as far as the valve before gas is

turned on—tapping in the main being made later through the opening in the service tee, as shown in the sketch,—where



Ill. No. 68.

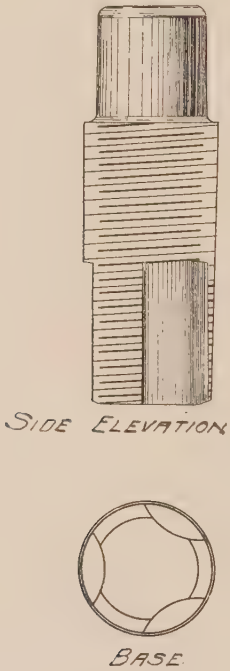
shank of drill passes through tight fitting in temporary plug to prevent the escape of gas.

JOHN SANDLES, Street Department,
Consolidated Gas Company of N. Y.

Ill. No. 68.

SPECIAL PLUG FOR HOUSE DRIPS.

A special slotted wrought iron plug for use in the bottom of inside drips makes it possible to loosen the plug and drain the water from the drip, which runs through the slots without entirely removing the plug from the thread, as the slots are



Ill. No. 69.

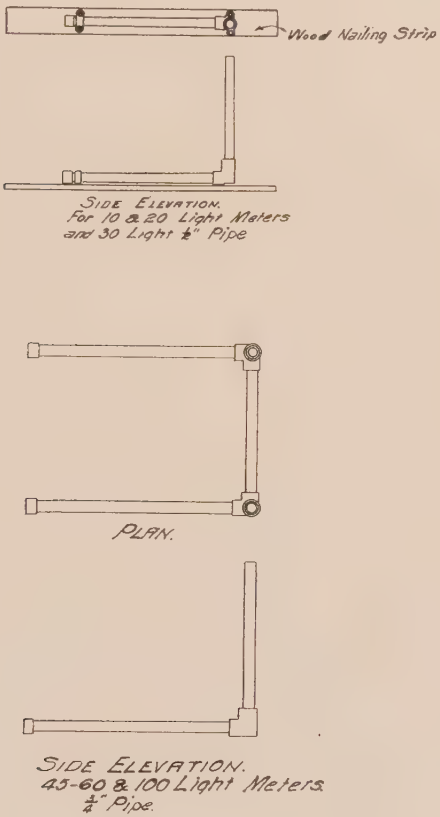
graduated the water can be slowly drained and the escape of gas is minimized, and the jumping of lights avoided that would attend the removal of the plug from the pipe should this be attempted while gas was being consumed.

WILLIAM GUNDEKHEIMER, Meter Department,
Consolidated Gas Company of N. Y.

Ill. No. 69.

METER BRACKET.

Meter brackets made of wrought iron pipe, as illustrated in sketch, can be used economically and to good advantage,



Ill. No. 70.

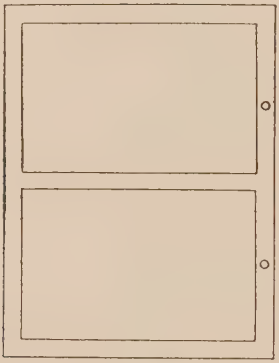
as they are very simple in construction and very serviceable in use.

W. J. WINROE, Meter Department,
Consolidated Gas Company of N. Y.

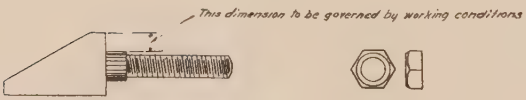
Ill. No. 70.

OVEN DOOR CATCH.

On certain types of gas ranges the oven door catch is made a part of the front casting, so that if it is broken it can only be repaired by replacing the front casting. If this catch was made separate from the casting and attached to it, the broken



OVEN DOOR
OF
PHOENIX RANGE
SHOWING
HOLES FOR PROPOSED CATCH.



PROPOSED CATCH.
FOR
OVEN DOORS of PHOENIX RANGES.

Ill. No. 71.

catches could be replaced on the district with much more economy than such repairs could otherwise be made. Such a form of catch is illustrated in sketch.

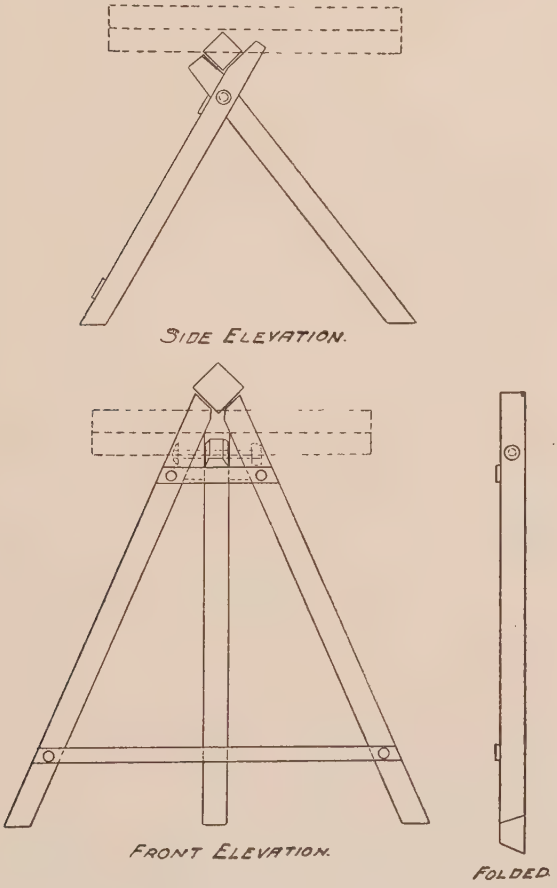
JOSEPH WARNER, Meter Department,

Consolidated Gas Company of N. Y.

Ill. No. 71.

STREET BARRICADE.

A form of folding barricade to protect street openings. This barricade is substantial and solid and its compactness



FOLDING STREET BARRICADE.

Ill. No. 72.

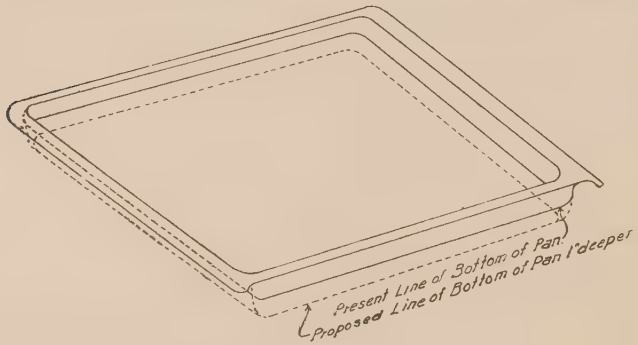
saves considerable space, both in transporting it and in storage.

EDWARD CORDES, Street Department,

Ill. No. 72. Consolidated Gas Company of N. Y.

DEEP BROILER PAN.

The broiler pans that are supplied with some gas ranges are



Ill. No. 73.

said to be unsatisfactory because of their shallowness,—grease often catching fire. The deeper pan illustrated in the sketch is believed to have overcome this.

EDWARD KANE, Meter Department,
New Amsterdam Gas Company.

Ill. No. 73.

VALVE AND DRIP BOXES.

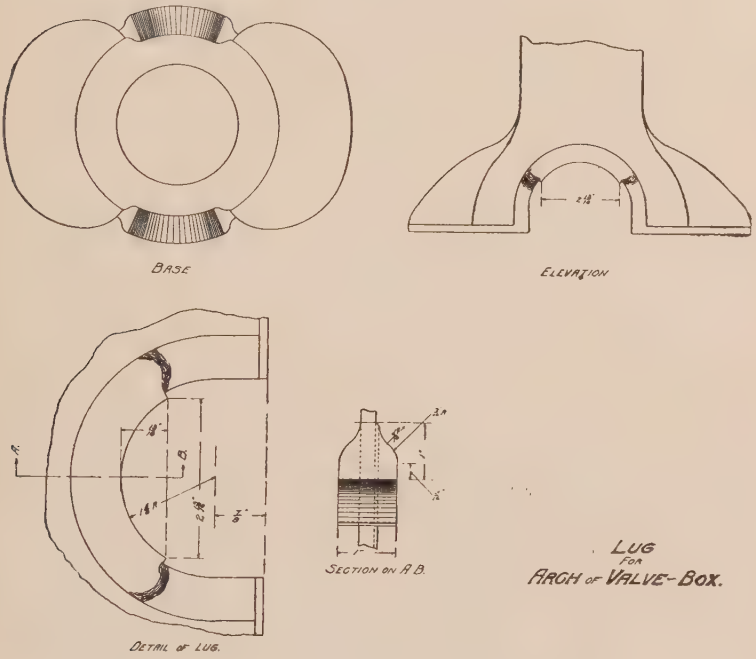
Service valve boxes and drip boxes, as ordinarily cast, have a sharp edge on that portion of the bottom section which is arched. In the event of settlement of the boxes, this sharp edge comes in contact with the pipe and the impact of heavy traffic might lead to breaking of pipe or wearing through at any time. Casting a flange on that section of the arch obviates this trouble, as shown by the sketch.

L. SCHIERMBOCK, Street Department,
Consolidated Gas Company of N. Y

Ill. No 74.

A RUBBER PLUG TO PREVENT GAS ESCAPING FROM MAINS WHILE LAYING SERVICE.

A form of rubber plug to be used when connecting service to main—by use of sectional sleeve—the object being, that after the sleeve has been placed on the main and the hole

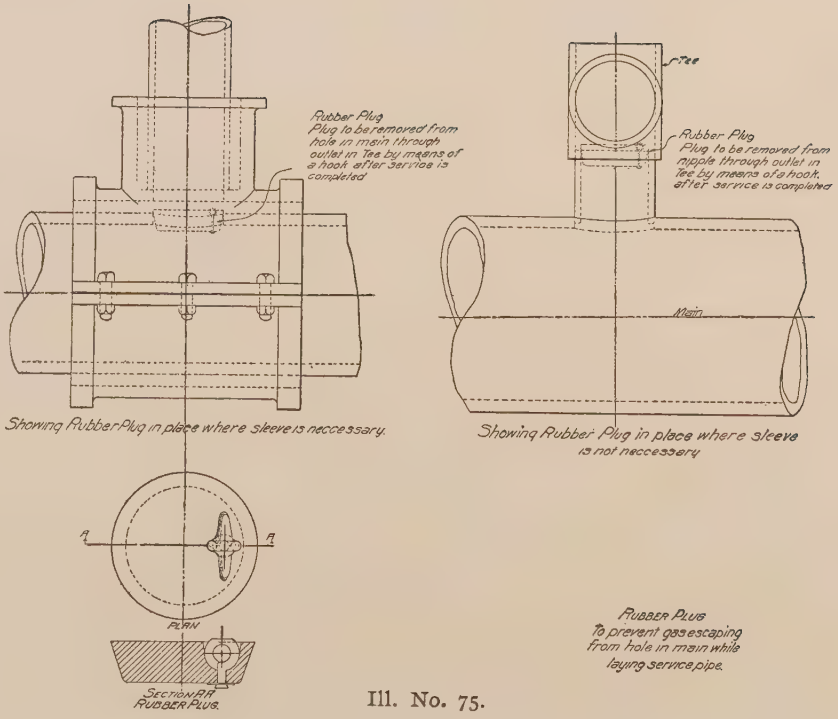


Ill. No. 74.

tapped in the pipe, the rubber plug is inserted in the tap hole and left there until the service has been completed, being withdrawn through the nipple and tee by special hook for that purpose. This illustrated by sketch.

J. F. Nelson, Street Department,
Consolidated Gas Company of N. Y.

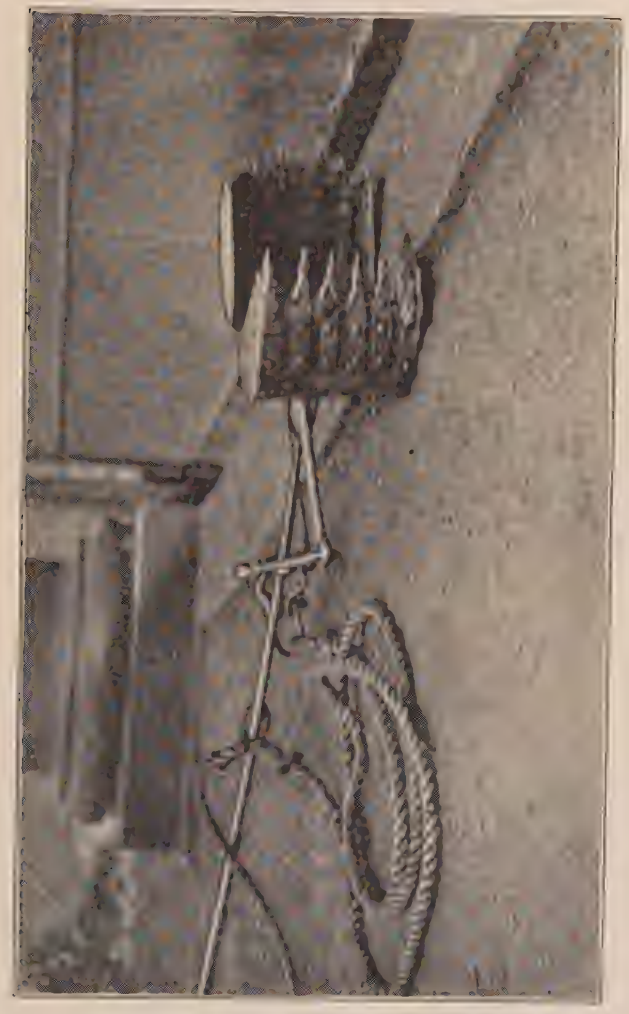
Ill. No. 75.


Rubber Plug
Plug to be removed from hole in main through outlet in Tee by means of a hook after service is completed
Showing Rubber Plug in place where sleeve is neccessary.
Tee
Rubber Plug
Plug to be removed from nipple through outlet in Tee by means of a hook, after service is completed
Main
Showing Rubber Plug in place where sleeve is not neccessary
A
A
PLAN
SECTION A-A
RUBBER PLUG.
RUBBER PLUG
To prevent gas escaping from hole in main while laying service pipe.

Ill. No. 75.

HAND OPERATED DIGGER.

For removing from gas holder tanks, any refuse or movable



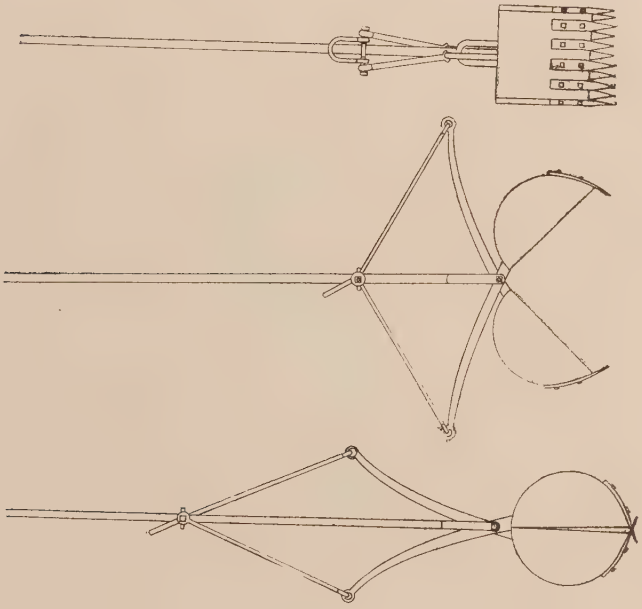
Ill. No. 76.

obstruction that interferes with the proper landing of gas holders on their landing stones.

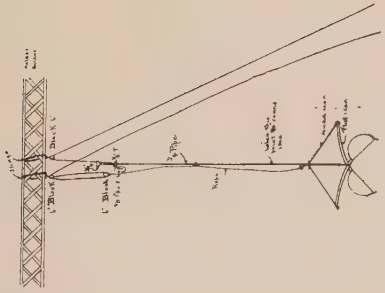
In the use of this form of digger, the holder should be

Ill. No. 77.

fully inflated to admit of the digger being properly passed between the sides of the tank and the bottom angle iron of



Ill. No. 78.



the holder. The digger should be attached over-head in a manner similar to that shown. The sketch represents the position of the digger ready to be lowered, the strain being

on the upright shaft, the jaws of the digger remaining open of their own weight. In lowering, the digger is guided and placed on the refuse to be removed and at the same time the attendant who guides the digger, places his foot on the offset in the shaft and presses the digger into the refuse, keeping his foot on the offset until the other attendants have closed the digger by hauling on the line that is attached to the toggle, and by which the digger and refuse is raised to the surface.

A digger of this construction has been used successfully for some years in tanks 25 to 30 ft. deep. For tanks of a greater depth larger pipe should be used for the shaft.

The labor required in using this apparatus is 3 men.

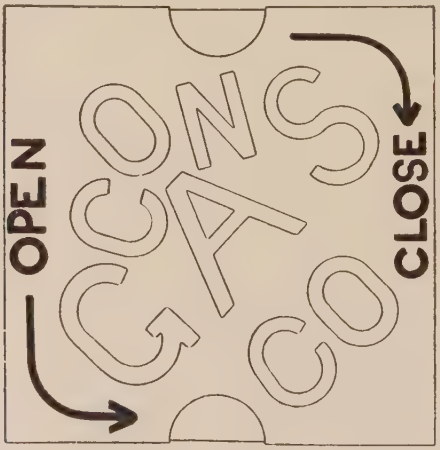
(Signed) A. RIBLET,

Supt. of 14th Street Works, Consolidated Gas Co. New York.

Ill. Nos. 76, 77, and 78.

VALVE BOX COVERS.

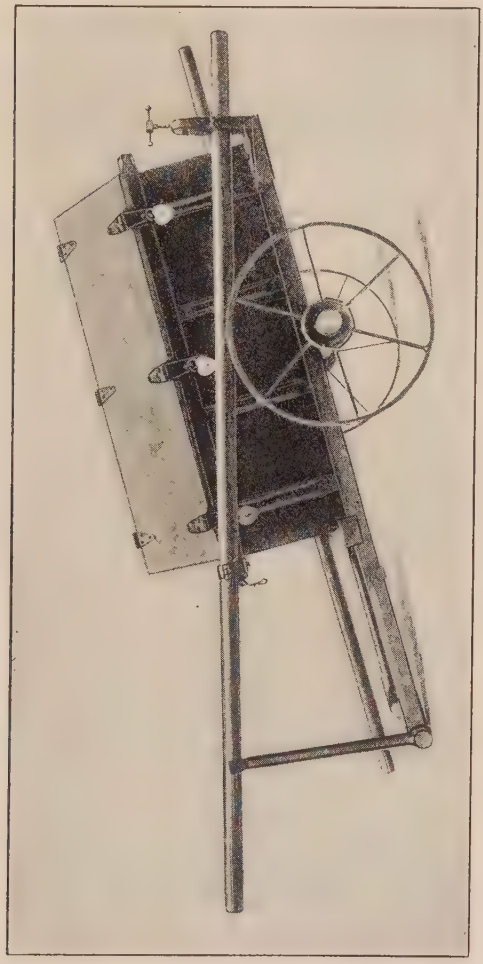
The covers used on service valve boxes have cast upon



Ill. No. 79.

them arrows indicating in which way the valve should be turned to open or close. While regular employees would hardly require that this information be placed before them, yet the use of this cover has lessened the breakage of valve

stems that occurred from time to time when members of the Fire Department or others attempted to open or close valves



Ill. No. 80.

without knowing in which direction they should be turned. (See sketch.)

E. J. Duffy, Street Department,
Consolidated Gas Company.

Ill. No. 79.

TOOL CART PIPE VISE.

The pipe vises with which service tool carts are equipped have customarily been placed on a support parallel to the bottom frame of the cart so that when a length of pipe was

Ill. No. 81.

placed in the vise and the cart shafts rested upon the street surface, the pipe was not in a horizontal position or in a position parallel to the bottom frame of the cart. With the thing to be cut thus pointing upward, the cutting and threading was made rather difficult, as the men could not get direct vertical pull on the handles of the pipe cutting or threading

machines. By beveling the support on which the vise rested so that when the shafts or handles of the cart rested on the street surface, the pipe was in a horizontal position it was found that the work of cutting and threading was made con-

Ill. No. 82.

siderably easier and the change was a decided benefit. The opposite end of the pipe is supported by a swinging arm attached to the cart shaft, as shown in the photograph.

LIONEL SEALE, Street Department,
Consolidated Gas Company of N. Y.

Ill. No. 80.

GENERATOR CHARGING CAR FOR WATER GAS MACHINE.

Special car, designed for charging fuel into water gas generator at 21st Street Station.

As represented in photograph the two outside changing holes are charged as shown, the fuel for the 3d or inside charging hole being run out on the floor and shovelled in by hand.

CHARLES F. KEEGAN, Supt.,
Supt. E. 21st Street Works,
Consolidated Gas Co. New York.

Ill. Nos. 81 and 82.

A METHOD FOR THE PREVENTION OF ENGINE CYLINDERS WEARING TO A SHOULDER ON BOTH ENDS OF THE STROKE WHERE A SOLID PISTON WITH TWO SNAP RINGS ARE USED.

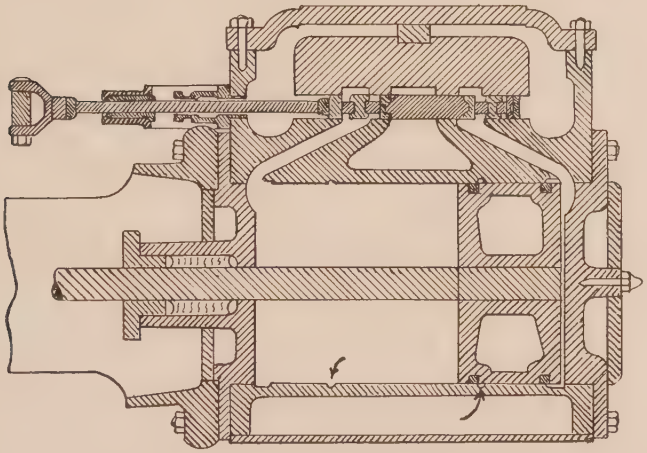
At 44th Street Works quite some difficulty was experienced in determining the cause of this trouble, as the cylinder would wear to a shoulder on both ends of the stroke at the second ring, causing the ring to break, which scored the cylinder so badly that we were compelled to rebore same at frequent intervals at great expense. After trying about everything we knew to remedy this trouble it was decided to rebore the cylinder once more, making a second counterbore or groove, which is located in the cylinder at the end of the stroke of the second ring (indicated by arrows). This prevented the shoulder being formed on the ends of the stroke. This method proved a success, as this engine would never run for a period of over a month, but since this change has been made it has been running constantly for eight months without any repairs.

W. J. HAWTHORN,
Supt. 44th Street Works, Consolidated Gas Co. New York.

Ill. No. 83.

REMOVABLE OIL HEATER FOR WATER GAS SET.

This is an oil heater made in the usual manner with several legs and return bends, and is placed vertically in take-off pipe. The inlet and outlet of heater are carried through vertical stuffing boxes placed on top of the cover of the pipe. This cover has an eye-bolt and connections to heater have valves and unions close to the stuffing boxes. A small chain block



A method for the prevention of engine cylinders wearing to a shoulder at both ends of the stroke, where a solid piston with two snap rings are used.

Ill. No. 83.

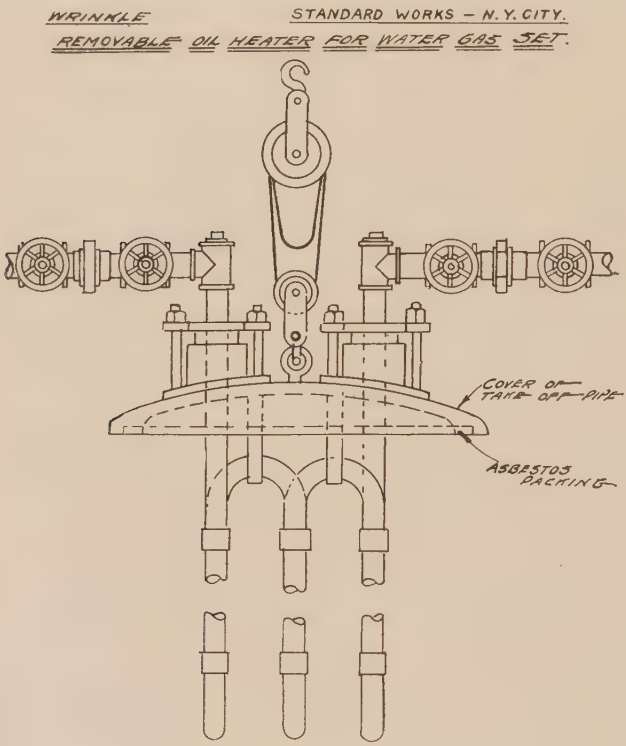
hangs over head. The heater can be quickly hauled up and lowered to a horizontal position on floor, thoroughly cleaned, and put back in place. This operation being done while fire is being clinkered, and is finished by the time fire is ready. The cover of pipe has an asbestos packing inserted in a groove, and obviates the making of a red lead joint.

JAMES S. KENNEDY, Supt.,
Standard Gas Light Co. Works, New York.

Ill. No. 84.

DEVICE FOR REMOVING STOPPAGES FROM SUCTION PIPES OF DRIPS.

The sketch shows the method we employ to remove any substance such as pieces of waste, pipe, yarn, etc., that may find their way into any of our drips, causing a stoppage

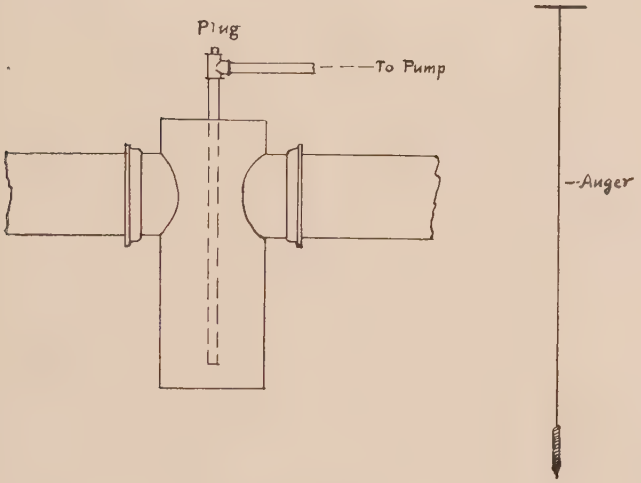


Ill. No. 84.

in the suction pipe. We were troubled for sometime in this way, and would attach steam hose, and blow back through line to clear it. This gave us only temporary relief as the pipe would again become clogged. On one of these occasions, after putting down a sounding rod, we found the substance felt like a wad of waste. It was then the idea came to

us to use the auger bit, as shown in the sketch. The result was that we were able to remove the cause of the trouble, and

Device for removing stoppages from Suction Pipes of Drips.



Ill. No. 85.

where formerly the trouble was a daily occurrence, it now occurs only at rare intervals.

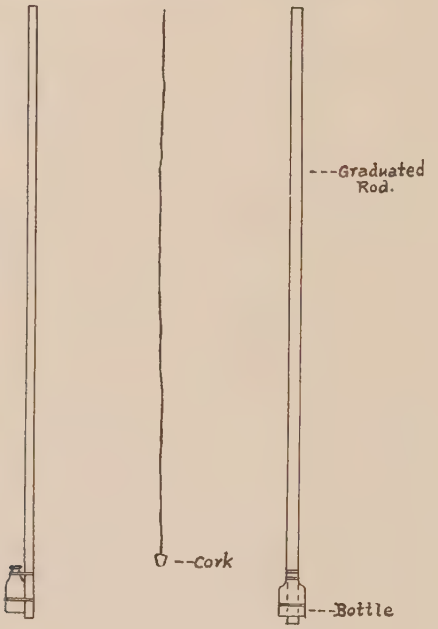
CHAS. F. KEEGAN,
East 21st Street Works, Cons. Gas. Co., New York.
Ill. No. 85.

DEVICE FOR SAMPLING CONTENTS OF OIL TANKS, ETC.

We have at our works a large square tank that is used to hold the condensation that comes back from our gas oil benches and condensers. This condensation consists of light oil, water, tar and a sort of emulsion. This emulsion will not separate by gravity, so it is pumped through a filter-press to separate it. This emulsion we find at different heights in the tank, so to locate just what height it is in the tank, we

use a rod graduated in feet and inches, with a bottle fastened at the end, with a long string attached to the cork, as shown in the sketch. We then immerse the bottle to any desired depth, pull the cork from the bottle and secure a sample

Device for Sampling Contents of Oil Tanks, etc.



Ill. No. 86.

This simple device enables us to locate the exact height of emulsion in the tank, and lower our swinging section accordingly.

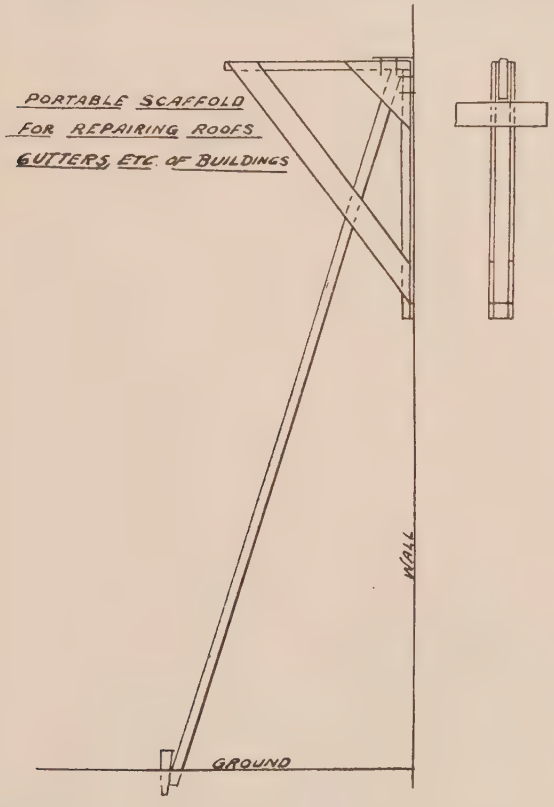
CHARLES F. KEEGAN, Supt.,

East 21st Street Works, Cons. Gas Co., New York.

Ill. No. 86.

PORTABLE SCAFFOLD FOR REPAIRING ROOFS, GUTTERS, ETC. OF BUILDINGS.

The accompanying illustration shows a convenient form of Portable Scaffold for the purpose named. Scaffold planks



Ill. No. 87.

are laid along the top of several of these triangular frames which are erected against the side of a building, without the necessity of making holes in same.

W. F. Lawrence, Gen'l Supt.,
Astoria Light, Heat & Power Co.,
Astoria, New York.

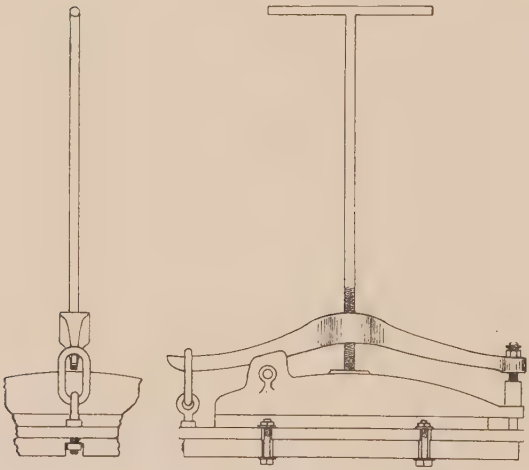
Ill. No. 87.

COTTER-BAR LINK FASTENING FOR CHARGING DOOR OF WATER GAS SET.

The toe of the cotter-bar passes through a link which is held by an eye-bolt secured to the seat casting as shown in sketch. This fastening is much more secure than the usual method in which a vertical bolt or shouldered pin in the seat

WRINKLE STANDARD WORKS — N.Y. CITY.

COTTER BAR LINK FASTENING
FOR CHARGING DOOR OF WATER GAS SET.



Ill. No. 88.

casting passes through an open end slot in the bar, and which is liable to be unshipped by a passing charging car.

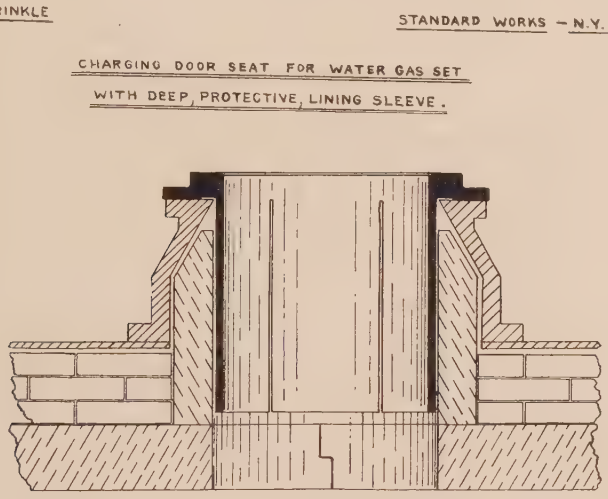
James S. Kennedy, Supt.,
Standard Gas Light Co. Works, New York.

Ill. No. 88.

CHARGING DOOR SEAT FOR WATER GAS SET.

The drawing shows the seat with deep protective lining

sleeve slotted to allow for expansion, and which effectually protects the brick lining of the charging hole from injury by the entering coal or fire bars. As the sleeve portion finally



Ill. No. 89.

burns out, the renewal expense can be lessened by constructing it in two parts.

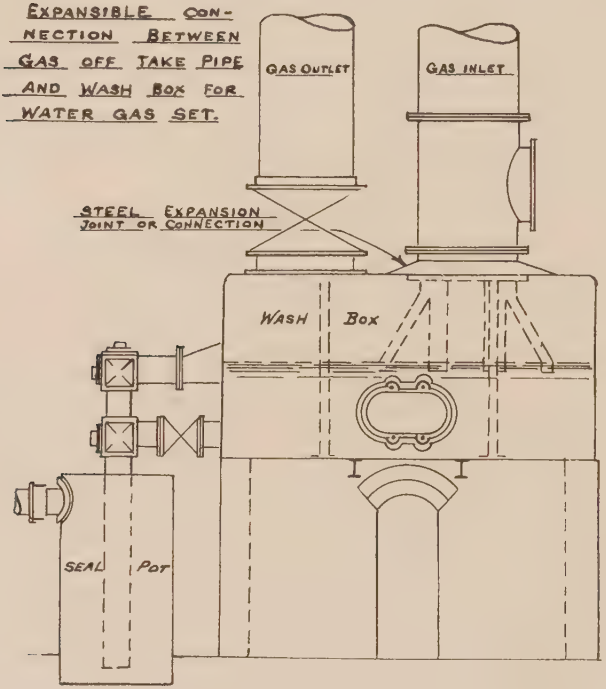
James S. Kennedy, Supt.,
Standard Gas Light Co. Works, New York.

Ill. No. 89.

EXPANSIBLE CONNECTION BETWEEN GAS OFF TAKE PIPE AND WASH BOX FOR WATER GAS SET.

The accompanying illustration shows a steel expansion joint or connection for the gas inlet pipe of wash box of a water gas set, to be used instead of the ordinary cast iron space piece. (As shown on left hand side of drawing, under valve.) With the cast iron space piece, it was found difficult to maintain a tight joint on top of wash box, and the steel space

piece was devised to obviate this difficulty, and has been


EXPANSIBLE CONNECTION BETWEEN GAS OFF TAKE PIPE AND WASH BOX FOR WATER GAS SET.
GAS OUTLET
GAS INLET
STEEL EXPANSION JOINT OR CONNECTION
WASH BOX
SEAL POT

Ill. No. 90.

found to be entirely successful.

W. F. LAWRENCE, Gen'l Supt.,
Astoria Light, Heat & Power Co.,
Astoria, New York

Ill. No. 90.

PURIFYING HOUSE H_2S TEST STAIN SHEET.

A handy record may be kept of the fouling conditions in purifying sets by using a form printed somewhat similar to the drawing, providing a space for a stain from each box. The paper used is a bibulous or absorbent paper and is sensitized by immersion in a saturated solution of lead acetate

and allowed to dry. Several sheets may be prepared at the same time.

Tests for stains are made by allowing the gas from each box to impinge on the surface of the paper through a cir-

WRINKLE STANDARD WORKS—N.Y. CITY.

PURIFYING HOUSE

H_2S TEST STAIN SHEET.

Date..... 19

Time.					
	Set 1	1st Box.	2nd Box.	3rd Box	4th Box.
	Set 2	1st Box.	2nd Box.	3rd Box.	4th Box.
	Set 3	1st Box.	2nd Box.	3rd Box.	4th Box.
	Set 4	1st Box.	2nd Box.	3rd Box.	4th Box.

Ill. No. 91.

cular orifice in a sheet of card-board, which must be large enough to protect from exposure all other parts of the sheet except the area designated by the number of the box under test.

JAMES S. KENNEDY, Supt.,
Standard Gas Light Co. Works, New York.

Ill. No. 91.

QUICK OPENING OIL VALVE AND LEVER FOR WATER GAS MACHINE

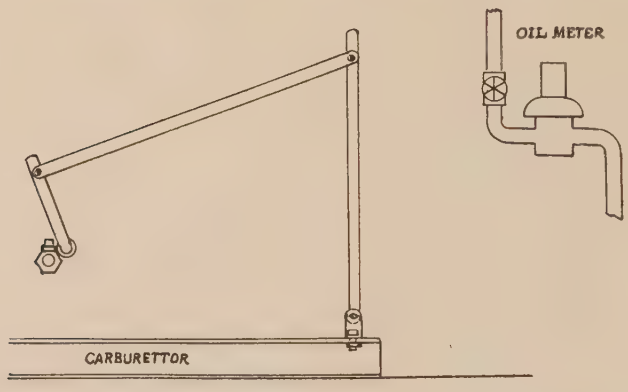
The valve used is the 1½ in. Patterson & Allen blow-off valve.

This arrangement gets the oil on the machine about 15 seconds sooner, and saves the gas maker an appreciable amount of walking.

Gas Makers Record Sheet Holder.

The accompanying photograph is one of our gas makers record sheet holders. It consists of a retangular shaped box

QUICK OPENING OIL VALVE AND LEVER FOR WATER GAS MACHINE



Ill. No. 92.

with sliding fluted cover, which the gas maker opens and closes when required. The sheet is held in place by thumb tacks preventing it from being blown away, while the cover enables the gas maker to keep a clean and tidy record and can be seen to the right in first photograph on gas makers small desk.

C. H. Hodges,
(Asst. Supt.) East 21st Street Works,
Consolidated Gas Co. New York.

Ill. Nos. 92, 93, and 94.

COTTER BAR TEE PIN AND NUT.

When thread on No. 8 Cotter Bar used on generator lids wears out, a nut as shown by enclosed sketch can be placed underneath the bar with a new cotter bar tee pin which

Ill. No. 93.

works satisfactorily and is more economical than purchasing new cotter bar.

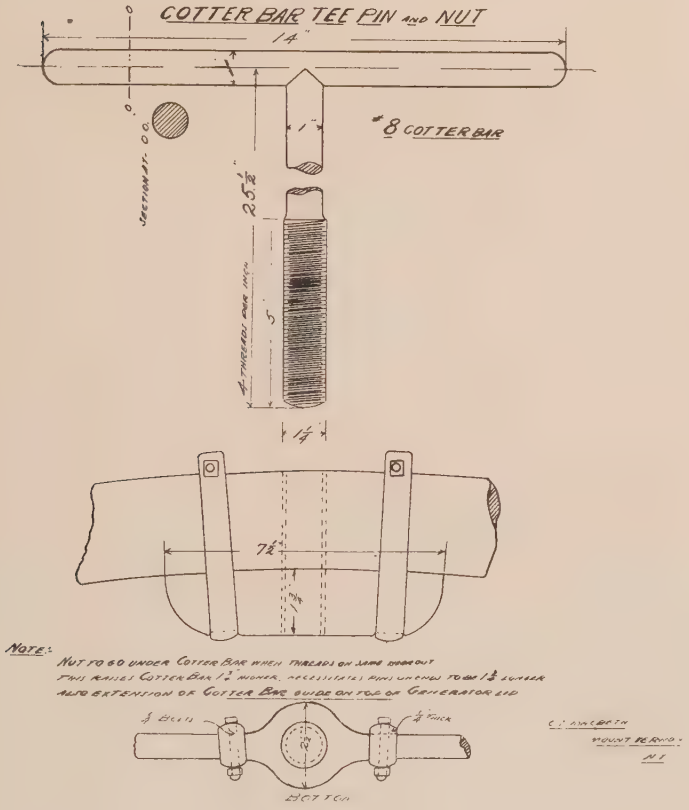
G. T. Macbeth,
Mt. Vernon, N. Y.

Ill. No. 95.

Ill. No. 94.

DIAGRAM OF A PIPING SYSTEM.

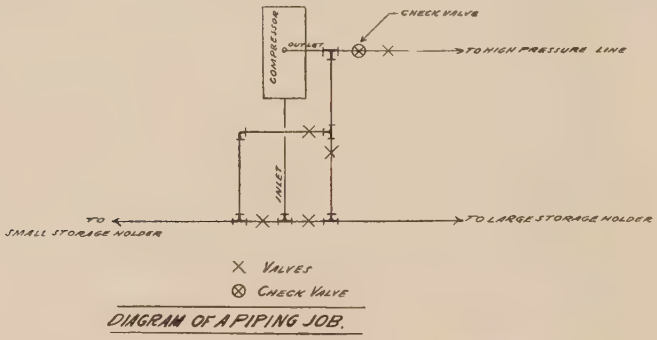
The diagram is of a piping job on a steam driven compressor. X are valves. (X) check valves. We make into the small storage holder and pump the gas from this holder to a



Ill. No. 95.

large storage holder, located about a mile from the plant, also to our high pressure line. By the above arrangement of piping and valves we are enabled to pump from either holder to high pressure line, also to transfer gas to either holder whenever it becomes necessary. The check valve (X)

is put in the high pressure line to prevent the gas escaping,



Ill. No. 96.

should a valve be left open in making changes.

H. M. Moore, Manager,
Austin Gas Light Co.,
Ill. No. 96. Austin, Texas.

MAGNIFYING DRAFT GAUGE.

The gauge is very convenient where small differences in pressure are to be read. The gauge was designed on the spur of the moment during a boiler test, the boiler running with "balanced draft." By its aid the drops in draft pressures from one part of the combustion chamber to another were easily determined to within 0.01 inch. The graduations representing 0.1 inch are in reality 0.5 inch apart, and the 0.1 inch can therefore be easily ascertained. The gauge should be set up so that there are equal readings on the two legs under atmospheric conditions. The whole gauge costs only a few cents and can be put together at any time within a half an hour. The construction is made plain by the sketch.

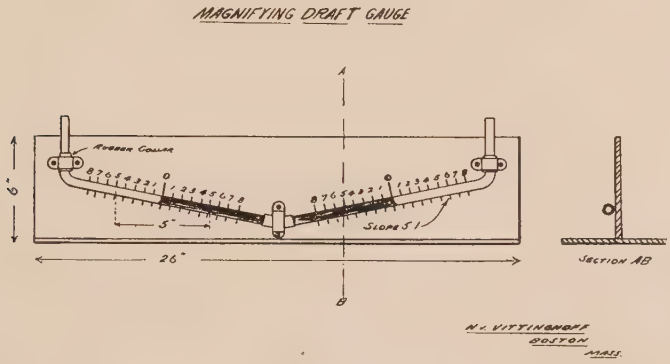
Hans von Vittinghoff, Stone and Webster,
Boston, Mass.

Ill. No. 97.

AN ADVERTISING SCHEME.

We secured from one of the novelty firms a number of celluloid buttons with design of Gas Kitchen thereon. Attached to these are metal chirping frogs. The buttons are numbered consecutively, and in the lot certain numbers are duplicated, there being as many duplicate numbers as we desire to give prizes.

The buttons were then distributed generally among the



Ill. No. 97.

school children and others. It was advertised that they were to be distributed with such duplicate numbering, and the prizes announced. Substantial prizes were offered to each person finding the other person holding the same number, the same prize being also given to the holder of the duplicate. If the prizes are made worth while and enough interest in the contest is stirred up, the holders of souvenirs will themselves advertise their numbers in the hope of locating the holder of the duplicate number.

Geo. W. Thomson,
Philadelphia Suburban Gas & Electric Co., Chester, Pa.

METHOD OF REPAIRING BREAK IN 24 IN. HOLDER OUTLET.

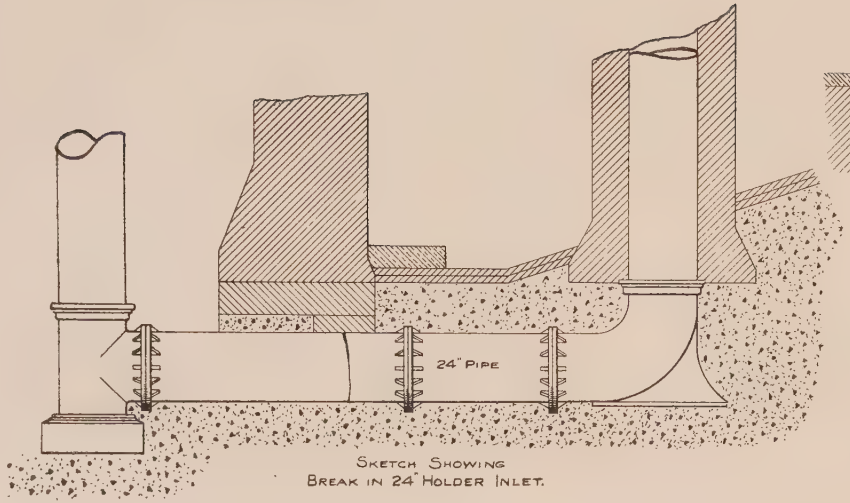
In 1907 the 24 inch outlet pipe to one of the holders at the Market Street Gas Works at Newark, N. J., began showing

an unusual amount of water. This increased to such an extent that eventually it became almost impossible to keep the drip clear and the pipe was abandoned for the time being.

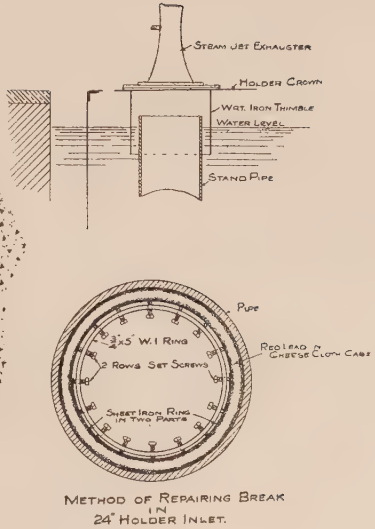
The holder tank was built in 1884 with its foundation touching on and in parts penetrating into the quick sand underlying the site. The tank had kept tight up to about the time of the trouble, when we noted cracks in the walls indicating a slight settlement.

In the spring following we let down the holder. This has a flat, unsupported crown, which floated upon the water of the tank when pressure was removed. Directly above the inner end of the inlet stand pipe there is a large manhole, which we opened and into which we inserted a short 30 inch flanged pipe, which effectually sealed off the stand pipe from the rest of the space under the crown. To the upper end of this flanged pipe we connected a steam jet exhauster. With this in action a strong current of air was drawn through the inlet pipe. After the same was thus thoroughly freed from all gas and odor our Assistant Engineer was lowered into outer end of stand pipe and then crawled into its horizontal leg to examine it. Upon coming up he reported having found a crack well around the circumference of the pipe, where shown in sketch. The weight of the wall settling on the pipe had evidently broken it and the outside water came freely through the crack. This we stopped temporarily by rubbing red lead into the break and then proceeded to repair it.

We made a stout solid ring about 19 inches in diameter of heavy flat iron. This ring we tapped for two rows of 5/8 inch bolts. The outer ends of these bolts we pressed against another but lighter ring of flat iron, about 20 inches in diameter, made in two halves, with overlapping ends. We prepared a sort of sausage made of stiff red lead putty enveloped in a canvas cover. This we placed over the crack along the circumference of the pipe and covered it with the above mentioned divided ring. Then we centered the heavy ring in the pipe and screwed out the tap bolts so that their outer ends



Sketch Showing
Break in 24" Holder Inlet.



Method of Repairing Break
in
24" Holder Inlet.

Ill. No. 98.

evenly bore against the lighter ring. We continued working the screws till the red lead bandage was firmly and evenly pressed against the sides of the main. This completed the repair work. To be sure the capacity of the pipe at this point is somewhat diminished but not appreciably so. The pipe has since remained absolutely tight. The cost of the job was comparatively trifling.

A. H. Strecker, Engineer,

Public Service Gas Co., Newark, N. J.

Ill. No. 98.

SPECIAL SERVICE SLEEVE.

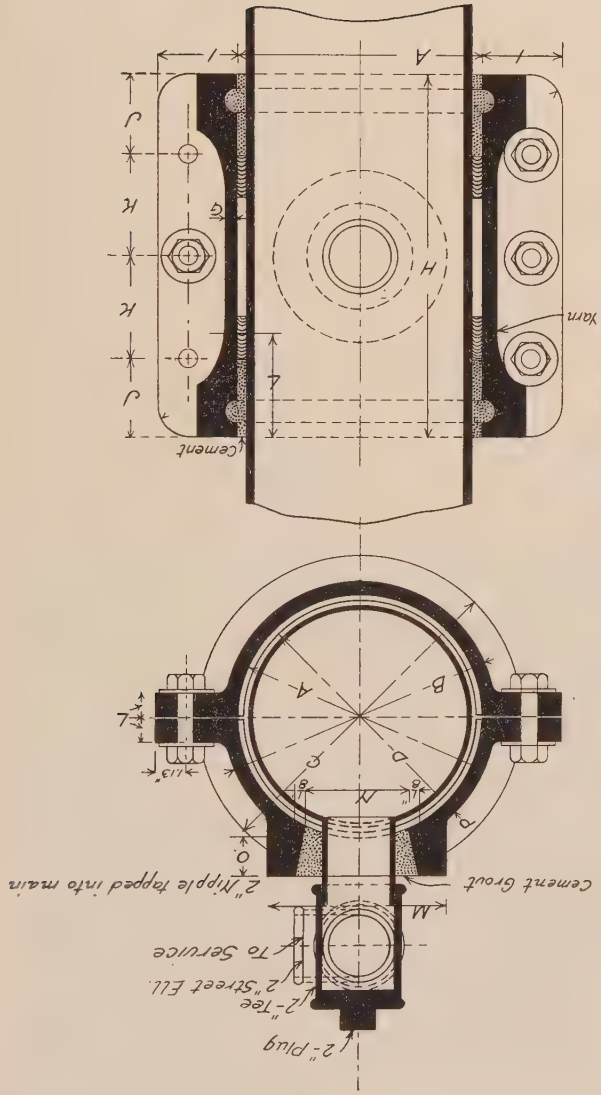
The method of using the sleeve is to first tap the main with the largest sized tap hole the main will stand and then insert a nipple piece after which the sleeve is placed around the main, as shown in the print, and the space between the main and the sleeve is then filled with cement after which the bolts are tightened; finally the space between the nipple and the sleeve is filled with cement grout. One man can do the whole job in twenty-five minutes. No gasket is needed between the flanges, and no special care is needed to make the sleeve gas tight, as the gas does not come in contact with the sleeve at any point. The nipple makes a gas tight joint, but mechanically weak, whereas the spit sleeve makes the whole job mechanically strong.

These sleeves are used, as for instance, in case where a 2½ service is to be run from 6 inch gas main or where a 1½ inch or 2 inch service is run from a 4 inch main. As far as we have gone with this device we feel that it is an improvement over the old method.

Jacob D. Von Maur, Sup't of Dist.,

The Laclede Gas Light Company, St. Louis, Mo.

Ill. No. 99.



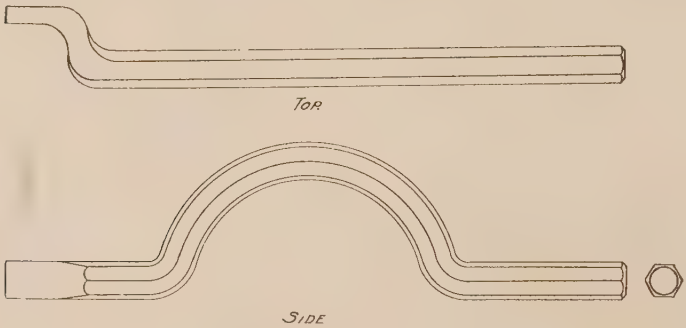
Dimensions in Inches

Size	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
4	5.80	6.60	8.40	5.55	4.00	3.00	4.0	12.00	2.88	2.56	3.30	7.5	4.00	2.5	1.00	1.00	5/8 Nuts
6	7.90	8.76	10.70	7.65	4.00	3.00	4.3	12.00	2.75	2.50	3.30	8.1	5.00	3	1.38	1.00	5/8 Nuts

Ill. No. 99.

CAULKING TOOLS.

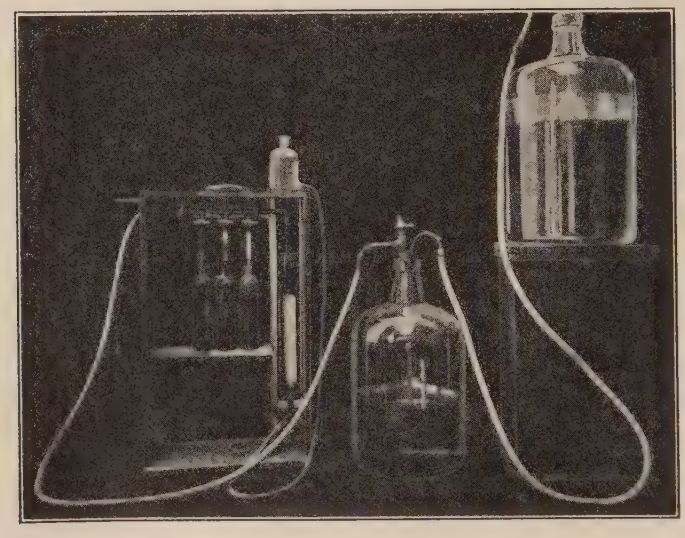
Special offset caulking tools, as per sketch, for use where caulking space is restricted, such as the under side of short



Ill. No. 100.

elbows where a short nipple is leaded into sleeve outlet with a horizontal line leading away from it.

E. J. DUFFY, Street Department,
Ill. No. 100. Consolidated Gas Co. of New York.



Ill. No. 101.

EQUIPMENT FOR SAMPLING BOILER FLUE GASES AND ORSAT APPARATUS FOR ANALYZING SAME.

This consists of three gallon and five gallon glass bottles with rubber connections for syphoning and aspirating.

CHARLES F. KEEGAN, Supt., East 21st Street Works,
Consolidated Gas Company of N. Y.

Ill. No. 101.

SOME PHILADELPHIA DISTRIBUTION FEATURES.

HANDLE FOR HOLDING LEAK BAR (ILLUSTRATED IN CUTS).

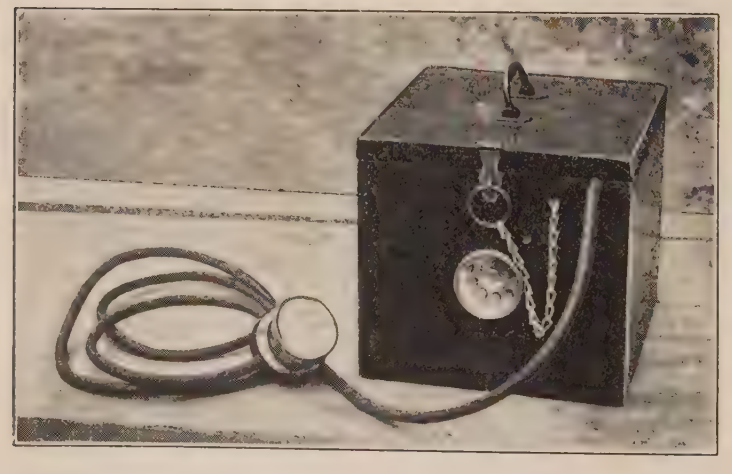
It is made of two (2) short shovel handles which have been

Ill. No. 102.

worn out, and when cut on a slant and bolted together so that the two (2) handles are parallel. It is slipped over a bar in

the manner shown and given a slight twist, affording a very

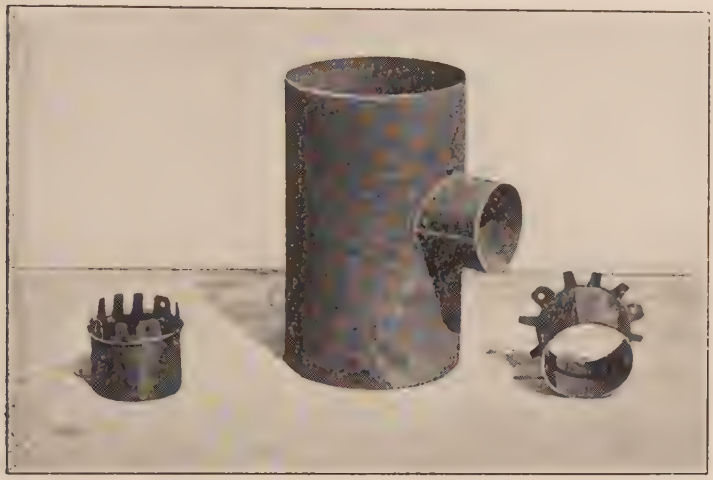
Ill. No. 103.



Ill. No. 104.

tight and rigid hold on the bar, which is of advantage with

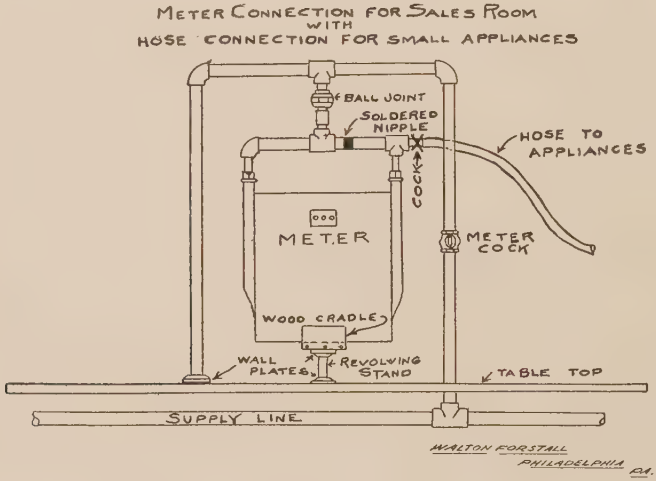
wedges for asphalt, etc., lessening chance of injury to the man



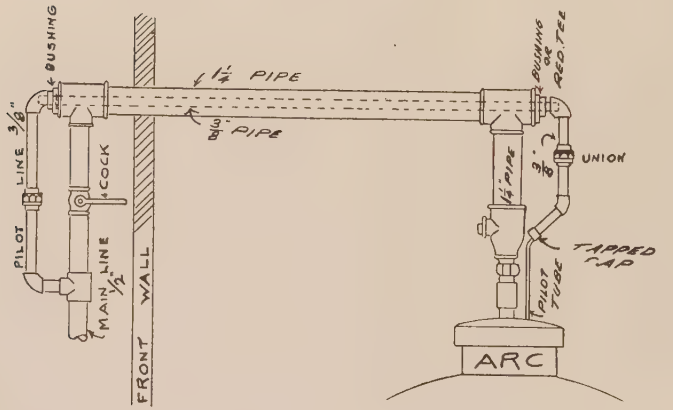
Ill. No. 105.

Ill. No. 106.

who would otherwise have to hold the bar or wedge while another was striking.



Ill. No. 107.



CONCEALED PILOT LINE FOR OUTSIDE ARCS

WALTON FORSTALL
PHILADELPHIA PA

Ill. No. 108.

DRY BATTERY LAMP FOR STREET LEAK WORK (ILLUSTRATED).

The electric dry battery lamp is housed in a box 10 in. by 11 in. by 9½ in. deep, with drop handle, hasp, ring to fasten lid and is water-tight, the same being dovetailed, and bottom of dovetails being put together with white lead. There is a bull's eye and reflector in the center of the front of the box, controlled by a switch on the left hand side of the box and a light on a cable ten (10) feet long, controlled by a switch on the right hand side of the box. This cable is No. 18 deck cable, used on shipboard. The bull's eye is made water tight. The current is supplied by 6 No. 6 Columbia dry batteries, three (3) in series and the two (2) series in parallel. The lamp used is a six (6) volt, two (2) candle-power minature battery lamp.

Although many lamps on the market of the storage type, are much smaller, they are not as easily re-charged as this lamp, because six (6) dry batteries can be purchased almost any where, thereby making the lamp independent entirely of a charging station.

HAT FLANGE FOR FLUE CONNECTION OF WATER HEATER

This hat flange is inserted in the smoke pipe of a coal range, for the purpose of connecting the flue from either a water heater or a gas range. The cylindrical hole is cut in the smoke pipe at the point of the proposed connection. The hat flange is then placed on the pipe and the notched ends are bent back with the fingers so as to form a clamp holding the flange to the pipe. In addition to this, there are three (3) small holes in the flange, through which are inserted 3/16 inch stove bolts. These are inserted with the head of a bolt on the outside. The flange is short enough so that the nut can be held in the fingers and the bolt screwed up from the outside with a screw driver.

CONCEALED PILOT LINE FOR OUTSIDE ARCS.

The pilot line is a ⅜ inch pipe inside of the main gas pipe, which is 1¼ inch. The method of connection may be seen from the drawing. The main gas supply is controlled within

the building, thus eliminating the necessity of any cock at the arc lamp.

METER CONNECTION FOR SALESROOM WITH HOSE CONNECTION

This sketch shows the method of connecting a small deducting meter to supply several appliances on a table, in a show room, or salesroom. The meter may be revolved so that it may be seen by prospective purchaser from either side of the table and the hose may be used to supply any appliance.

WALTON FORSTALL,
Philadelphia, Pa.

Ill. Nos. 102, 103, 104, 105, 106, 107, and 108.

ARRANGEMENT TO PREVENT THE FORMATION OF A VACUUM ON THE TAKE-OFF PIPES OF WATER GAS MACHINES.

Sketch No. 1 showing arrangement of apparatus and location of engine-governor. The point "A" is connected to the drum of the governor by a ¾ in. pipe. The governor is counterbalanced so that when the pressure at "A" becomes zero, the drum falls, thus closing the throttle valve on the engine. The arrangement is shown in more detail on sketch No. 2.

E. L. SPENCER, Supt.,
Central Union Gas Works,
New York.

Ill. Nos. 109 and 110.

BRICK HOPPER.

This hopper was gotten up to replace similar sheet iron hoppers. The hot coke is drawn direct from the retorts into the hopper and quenched there.

The iron hoppers warped and burnt out rapidly.

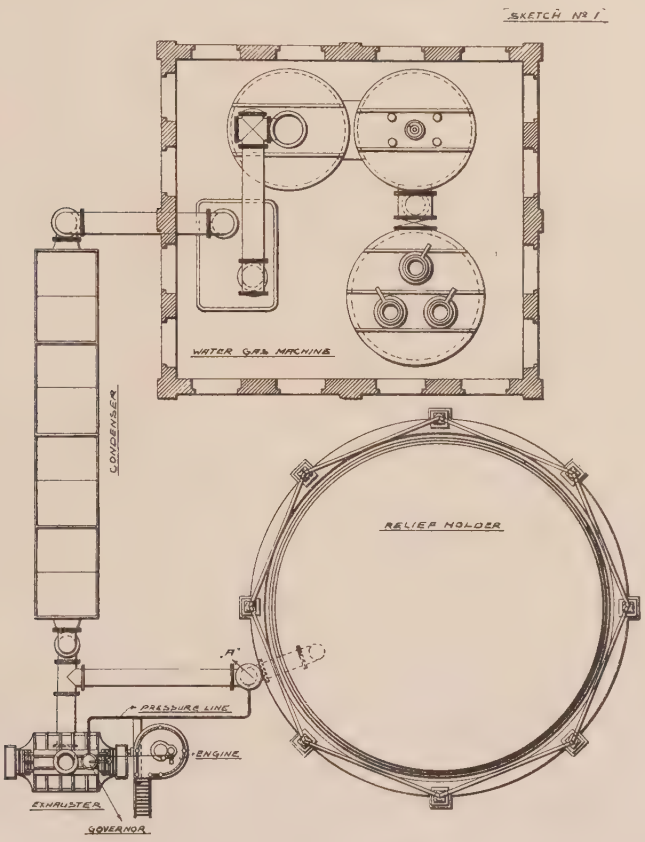
The brick hoppers have been in use for over a year and stand the severe service very well.

ALAN D. WHITTAKER, Supt. of Works,
Atlanta, Ga.

Ill. No. 111.

A Device for Locating Leaks in Mains.

A piece of ½ in. pipe long enough to reach the main is



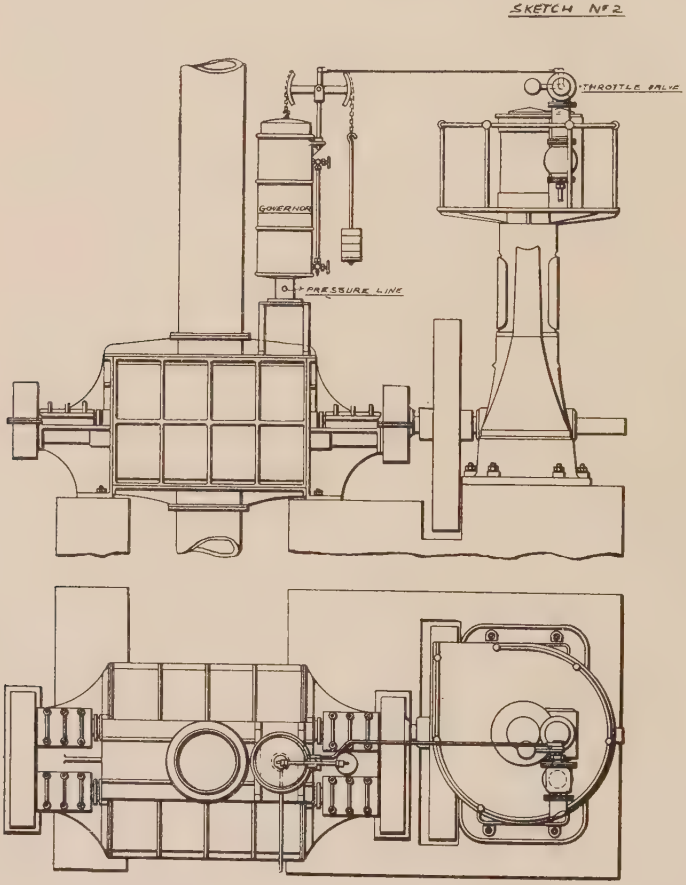
WRINKLE SUBMITTED BY E.L. SPENCER
CENTRAL UNION GAS CO.

ARRANGEMENT TO PREVENT THE FORMATION OF A VACUUM ON THE TAKE-OFF PIPES OF WATER GAS MACHINES. SKETCH SHOWING ARRANGEMENT OF APPARATUS AND LOCATION OF ENGINE-GOVERNOR. THE POINT „A" IS CONNECTED TO THE DRUM OF THE GOVERNOR BY A ¾ IN. PIPE. THE GOVERNOR IS COUNTER-BALANCED SO THAT WHEN THE PRESSURE AT „A" BECOME ZERO, THE DRUM FALLS THUS CLOSING THE THROTTLE VALVE ON THE ENGINE. THE ARRANGEMENT IS SHOWN IN MORE DETAIL ON SKETCH Nº 2.

Ill. No. 109.

pointed and slotted, with one edge of the slot turned out-

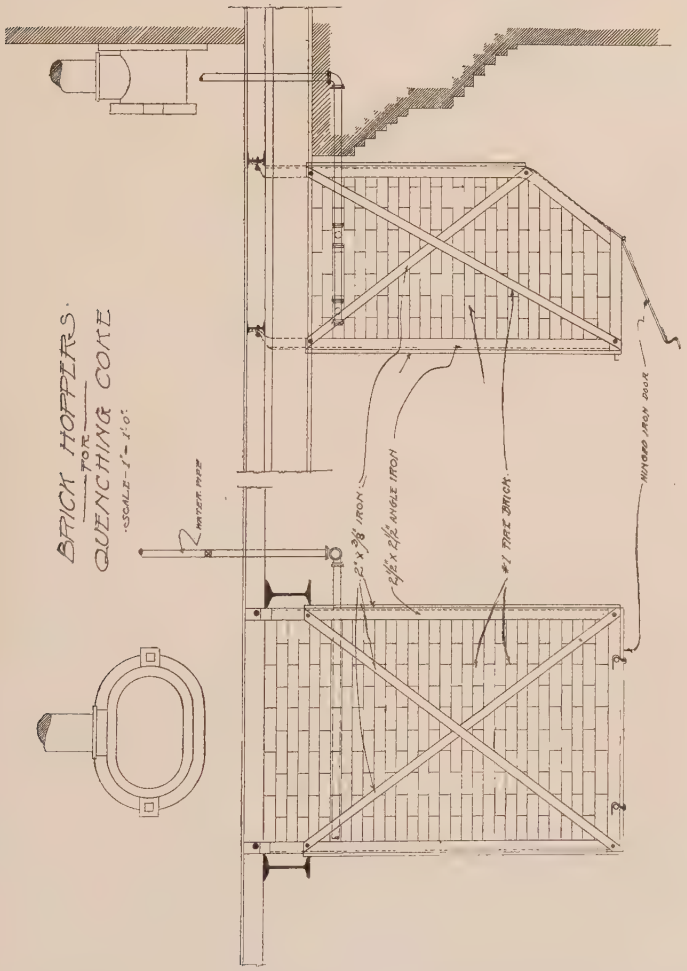
ward, so that when the pipe is thrust down a bar hole, and


SKETCH Nº 2
THROTTLE VALVE
GOVERNOR
OIL PRESSURE LINE
WRINKLE SUBMITTED BY E.L. SPENCER
CENTRAL UNION GAS CO.
ARRANGEMENT OF ENGINE-GOVERNOR TO PREVENT THE FORMATION OF A VACUUM ON THE TAKE-OFF PIPES OF WATER GAS MACHINES.

Ill. No. 110.

twisted, a sample of earth is brought up from near the

joint. It often happens that a leak is large enough to sat-



Ill. No. 111.

urate the surrounding earth and yet not be easily detected by smelling at the surface of the ground.

J. D. Alden, Asst. Supt.

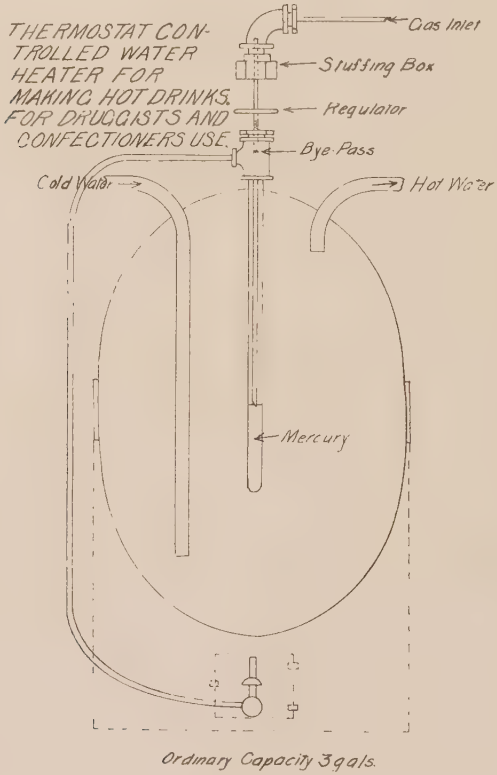
Holder Tell Tale.

A time recording gauge is connected, through a reducing

motion, to the relief holder. The record obtained shows the height of the holder at any hour during the days run.

Meter Test Cap.

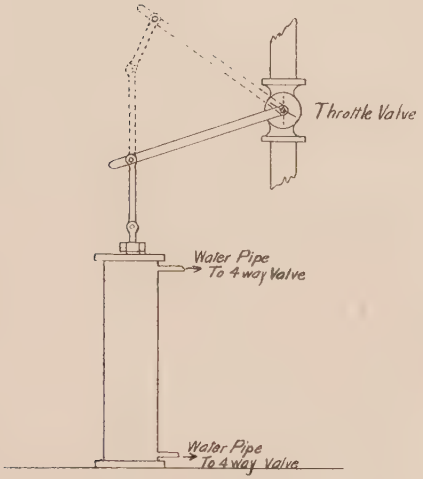
This is a substitute for the corks often used in meters



Ill. No. 112.

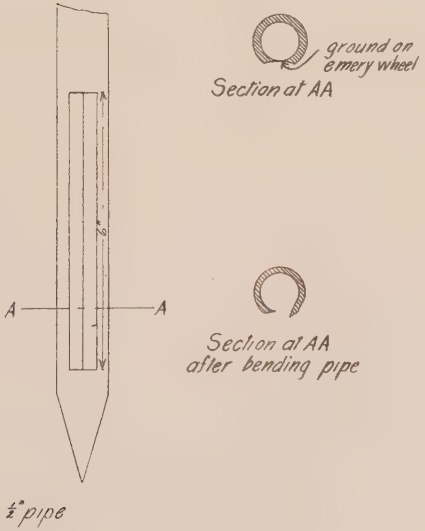
which have been shut off but left in place. It has the following advantages: It does not leak, can be used repeatedly without injury, is not so readily detected as the cork, and is more easily inserted and removed. It is made of 0.010 gauge sheet brass.

ENGINE STARTER



Ill. No. 113.

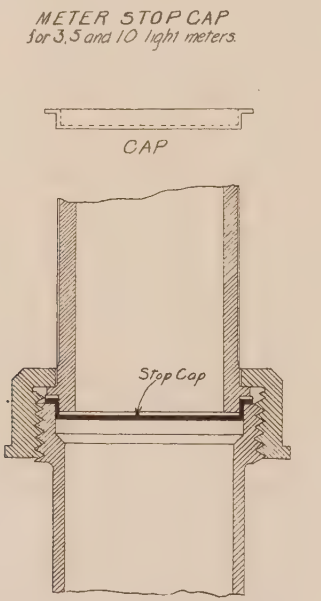
DEVICE FOR SAMPLING EARTH AROUND MAINS TO DETECT LEAKS.



Ill. No. 114.

Engine Starter.

This is a means of starting and stopping the blowing engine to prevent waste of steam. The four-way hydraulic valve or lever operating the stack valve, operates also valves controlling the water supply to the top and bottom of the hydraulic cylinder at the engine, thus closing the throttle during a run. When the throttle is closed, the engine is kept slowly turning through a ½ in or ¾ in by-pass.



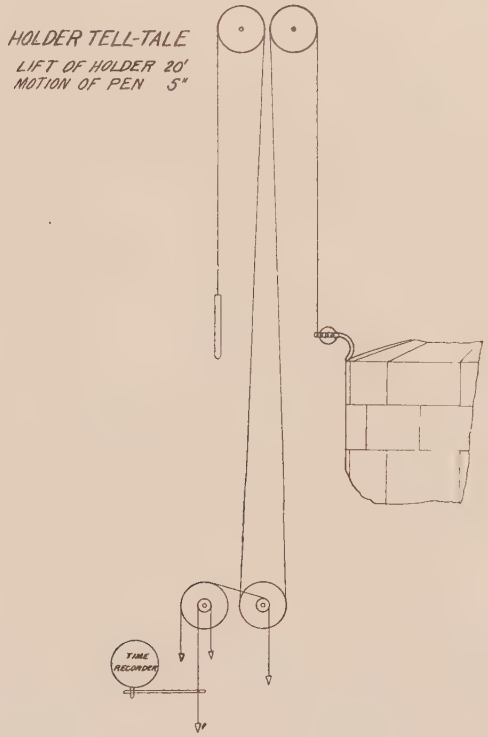
Meter inlet union showing cap inserted.

Ill. No. 115.

Connection for Heating the Holders with Exhaust Steam.

The exhaust steam from the various engines is utilized to heat the holder tank water. To prevent siphoning back the water from the tank when the machinery is shut down, a vacuum valve is installed. This is an ordinary vacuum valve such as is used on locomotives. In this case the valve

is turned down, instead of upward, as on a locomotive, so that the weight of the disk helps to keep it closed. This is necessary because of the low pressure of the exhaust steam.



Ill. No. 116.

Thermostat Controlled Water Heater.

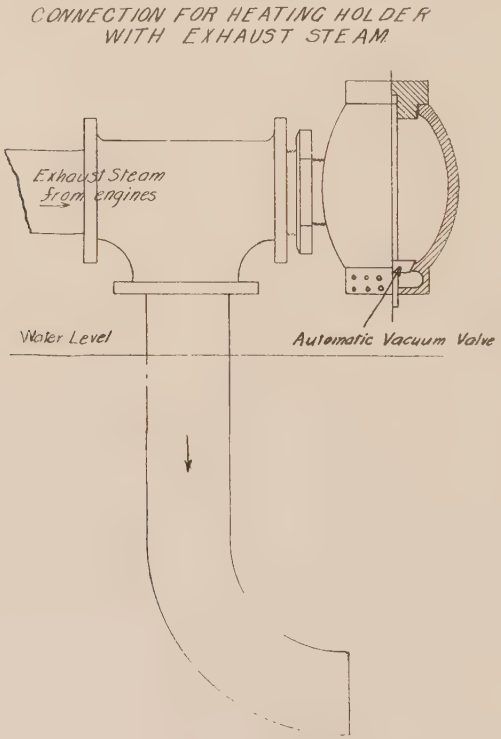
Druggists and confectioners require for the making of hot drinks a supply of water of nearly constant temperature.

This device gives this with the minimum consumption of gas, and the minimum of attention. A small boiler without vent is used, with the water supply always turned on. The gas supply to the burner underneath is brought through a small pipe, bevelled at the end, and nearly sealed in mercury, as

shown. When the temperature of the water increases, the level of the mercury rises, and shuts off the gas. A regulating wheel permits the adjustment of the dip pipe, and consequently the control of the temperature at which the gas is shut off.

Support for Inverted Lamps.

The sketch shows a bracket which may be made from

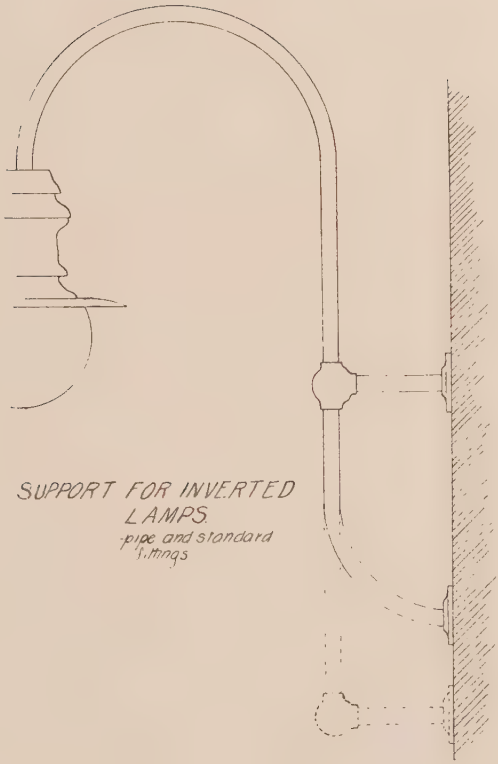


Ill. No. 117.

standard pipe and fittings and can be attached to the side or front of the building.

E. Williams, Supt.

Ill. No. 112, 113, 114, 115, 116, 117 and 118.



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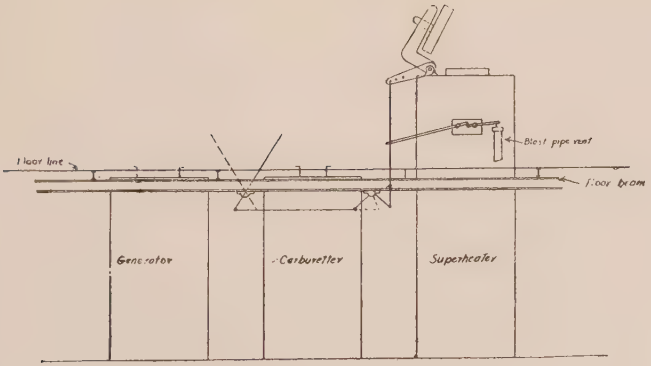


Ill. No. 119.

IMPROVED STACK VALVE LEVER.

The above sketch shows an arrangement for lifting and closing stack valve, so that the gas maker does not leave the immediate vicinity of the generator blast and steam stands in operating it. This saves considerable time during a 24 hour operation of a set with a consequent result of increased capacity.

B. S. WALTERS, Manager.

Ill. No. 119. So. Bend, Ind.

MR. PRESIDENT: Gentlemen, you have listened to the report of the Chairman of the Wrinkle Department. If there is no objection, the report will be received and placed on file.

The next is the report of the

BUREAU OF INFORMATION.

Mr. V. F. Dewey, Chairman.

Is Mr. Dewey present?

(No response.)

The Secretary informs me that the report of the Bureau of Information has been printed and distributed to the members, so we will omit reading it.

REPORT OF THE BUREAU OF INFORMATION FOR THE YEAR 1910.

The Committee in Charge of the Bureau of Information submits the following report upon the work accomplished during the year 1910. The Committee in Charge of the work for 1909 completed all of the work presented to them and turned over to the present Committee a clean slate.

During the past year there have been submitted for answer fourteen questions, numbering from 57 to 70 inclusive. Answers to all of these questions are hereby submitted.

The plan of carrying on the work has been somewhat different from the past years. The membership of the Committee was reduced to five members. Few questions were submitted to the members of the Committee for answer.

Instead, they were asked and expected to find someone qualified to give an answer to the question that was submitted to them. The names of the persons answering the questions have been submitted with the answer; the answer being edited, and in some cases revised, by the Committee in Charge of the Bureau of Information. This method of procedure lightened the work of the individual members of the Committee and at the same time put them in touch with persons who were qualified to give adequate answers to the questions submitted to them from previous experience and present data without being an undue hardship to any one, such as the requiring of experimental work before the question could be answered.

No questions submitted have been rejected.

The Committee wishes to extend its thanks to both of the Gas Journals. They have rendered great and valuable assistance to us in carrying on the work.

It is perhaps unfortunate that the members of the American Gas Institute do not make greater use of the Bureau of Information. Fourteen questions surely do not embrace all of the difficulties and problems that are encountered in the year by the gas men of America. The limited amount of work that is put to the Bureau of Information tends to a slackness in organization which would be remedied if more work were required of the Bureau. Several times as many questions could be answered with very little more work.

Respectfully submitted,

H. C. Abell,
W. S. Blauvelt,
R. M. Searle,
J. D. vonMaur,
V. F. Dewey, *Chairman.*

Question No. 57.

In the process of condensation what is the proper temperature to extract tar from coal gas, having in view:

(A) Retaining in the gas the maximum amounts of illuminants.

(B) The absorption of naphthalene with the end in view of reducing to a minimum its deposition in the mains after it leaves the Station Meter.

ANSWER.

Section (A) First, assuming that Section (A) presupposes the removal of a major portion of the tar in the gas after it leaves the hydraulic main by the use of an impact tar extractor such as the Pelouze and Audoin type, the answer would resolve itself into the proper temperature to pass the gas through this instrument, getting a high removal efficiency, yet retaining the maximum amount of illuminants in the gas. A temperature at the inlet of the P & A ranging between 100 and 115° F. is a safe margin within which to operate. The following tests were made starting at a temperature of 135° at the inlet of the P & A. After temperatures and other operating conditions were more or less constant, hourly candle power tests were taken for a period of 24 hours, with a reduction of temperature at the inlet of the P & A of 5° at a time. No marked change in the candle-power for any one run was recorded until the temperature was reduced from 95 to 90°, when a drop of one candle-power was noted. This drop in candle-power was verified several times by raising and lowering the temperature between 100 and 90°. At a temperature above 115 degrees the vapor tension of the gas was too high to make the P & A effective on a reasonable differential.

Second, assuming in the process of condensation that the removal of the tar from the gas is accomplished by no particular extractor or vessel, but by a series of condensers, washers, scrubbers, etc., then the answer would involve a condensing system so well designed and ample as to bring about a gradual cooling of the gas. A slow and uniform condensation, free from any sudden drop in temperature will maintain an equilibrium that will minimize the deposition of il-

luminants. The danger in operating without a special tar extractor is in having a limited and faulty condensing system. In this case, it would be impossible to remove the tar in any way that would retain the maximum illuminants and keep the condensing vessels free from naphthalene. The gradual removing of the tar presupposes a set of condensing vessels ample in capacity and well designed. It has been clearly proven by a number of companies that the gradual removal of the tar in the condensers, washers, etc., not only retains the maximum amount of illuminants in the gas, but the tar at the different temperatures of removal either forms a solvent for the naphthalene or mechanically washes the naphthalene, which forms on the surfaces of the vessels, down into the drips.

Following is a brief synopsis of the operating conditions of a plant extracting the tar with the P & A by-passed. The gas leaving the foul main is kept down to a temperature between 125 to 135° F. by means of a water cooled circulating system of liquor through the hydraulic main. This wash in the main causes a precipitation of a great amount of the heavy and lighter tars which otherwise would be carried over to the condensers, etc. The fluidity of this tar in the main automatically keeps it clear and free from pitch formation. The gas is pulled by the exhauster through a primary water tube condenser, the temperature never being reduced more than 10 or 15° in this vessel. It is then pumped through the various condensers and the work done in each is so adjusted as to reduce the temperature equally in each one. The temperature of the gas entering the tar washer should never be above 75° or below 65°. The outlet of the rotary scrubber will show an increase of from 5 to 7° over the inlet temperature.

O. A. Sinsel, Supt.,
Detroit City Gas Company.

Section (B) The illuminants in gas may be divided into the two classes of fixed gases and vapors. The fixed gases with ethylene as the most important member will not be

materially removed from the gas by any ordinary condensing process. The other class, vapors, with benzol as the most important member are always partially removed by the tar and the question to be considered is really that of equilibrium between the solvent power of the tar for these vapors and their vapor tension which tends to keep them in the gaseous state.

The removal of naphthalene through the agency of the tar in the condensing process is brought about in the same way as the removal of benzol, for benzol and naphthalene are closely related hydrocarbons. The fact that benzol is a liquid and in high favor and that naphthalene is a solid and a nuisance does not constitute an essential difference.

The theory of the condensing process may be stated as follows: As the gases issuing from the retort cool, the constituents with high boiling point are the first to separate in extremely minute globules forming "fog." These globules by impact against each other coalesce to form large globules which settle out through their own weight or are held fast by the tarry surfaces of solid substances with which they come in contact. At lower temperatures substances of lower boiling point commence to condense. If this were the whole story it would evidently be the proper course to cool the gas to just the boiling-point of benzol, 177° F., remove the condensed tar and water mechanically and then proceed with further condensation. However, the case is not so simple for the tar will have dissolved some of the benzol vapors even above their boiling point so that it is not possible by any simple scheme of condensation to prevent part of the benzol from passing off with the tar. The amount thus dissolved will vary mainly with the temperature at which the tar is separated. The same principle holds true for naphthalene. The practical conflict comes from the fact that it is desired in one and the same condensing operation to remove from the gas more than 99 per cent. of the naphthalene and to leave in the gas practically all the benzol. The two things are incompatible

and the result is a compromise. It is therefore not possible to state the best temperature for the separation of the tar. It will vary with the temperature of the retorts, the coal used, and the arrangement of the condensing system. It is generally believed that if the tar is not separated before the gas cools to 100° F. there will be loss of candle-power.

It is frequently held on the other hand that if the tar is removed at as high a temperature as 120° F. there will be naphthalene troubles. There is at least a probability that naphthalene troubles under these circumstances are due in part to incomplete mechanical removal of the tar which becomes more difficult at higher temperatures. If tar carrying much naphthalene reaches the scrubbers there may sometimes be liberation of naphthalene there due to the action of ammonia on the phenols of the tar. Some works are, however, able to remove the tar at higher temperatures with presumably better candle-power results.

While it is therefore not possible to give a definite answer to this question it is apparent from what precedes that, in the operation of a simple condensing system without naphthalene scrubbers or subsequent benzol enrichment, the best results as to candle-power will be obtained by removing the tar at high temperature. This may sometimes cause naphthalene trouble but probably not necessarily so. Data as to the effect of complete removal of tar at higher temperatures are lacking and it is extremely desirable that careful tests should be made on this point.

Prof. A. H. White,
University of Michigan.

Question No. 58.

Is it common practice in making specifications for the purchase of iron pipe to insert a clause relative to the chemical composition of the pipe; and if so, what chemical analysis should be required.

Answer.

It is not a common practice in making specifications for the purchase of either cast iron, wrought iron, or steel pipe to

insert a clause relative to the chemical composition of the pipe; although it is sometimes done, as for instance in the specifications for the riveted steel pipe used at Cambridge, Mass., under specifications drawn by the City's Chief Engineer, Mr. L. M. Hastings, and which are published in the "Engineering News" of Jan. 18, 1895. These specifications contain the following clause:—

"The steel for plates used for the manufacture of the pipe to be of the class termed 'soft' and shall be made by the open hearth process. It shall contain not more than 6/10 per cent. of phosphorus, 6/10 per cent. of sulphur, or 6/10 per cent. of manganese."

It is also not customary to specify the chemical composition of cast iron pipe.

In the specifications laid down by the New England Water Works Association it is specified that all pipes and special castings shall be cast iron, of good quality, and of such characteristics as shall make the metal of the castings strong, tough, and of even texture and soft enough to satisfactorily admit of drilling and cutting. The metal shall be made without any admixture of cinder iron or other inferior metal, and shall be re-melted in a cupola or air furnace.

Except in rare instances or in Works of exceedingly great importance, or where the pipe is to be used for some special purpose it would be inadvisable to specify the chemical composition of either cast iron, wrought iron, or steel pipe as it is very unlikely that manufacturers would accept such an order, except on the basis of increase in price, and it would then be necessary for the purchaser to arrange to have analyses made continually, in order to make sure that the pipe received is exactly as specified, and finally it is quite likely that if the iron mixture is specified by the purchaser he would have to take the responsibility of the resulting product.

The following analysis of cast iron pipe has proved to be very satisfactory in practice:—

Silicon	2.033
Sulphur	0.039
Combined Carbon	0.900
Manganese	0.370
Graphite	2.470
Phosphorus	0.757

J. D. vonMaur, Supt.,
Laclede Gas Light Company, St. Louis.

Question No. 59.

What relation exists, in the operation of a water gas machine, between the amount of air per minute per square foot of grate area during blast, and lbs. of carbon per M. feet of gas made and make of gas per hour?

Answer.

In running a generator of 50 square feet grate surface with a positive blower, and making 21½ candle-power gas with 3.9 gallons of oil, 2¾ minute blow, 5¼ minutes changing valves and steaming, it was found that 225 cubic feet of air was used per cubic foot of grate surface per minute, of which 144 cubic feet was used in the generator and 81 cubic feet as secondary air.

The make was 13,830 cubic feet per run, or 10,000 per hour, or 2,000 cubic feet per square foot of grate per hour.

From a long series of observations it appears that, with the same fuel, the lbs. of carbon per M. feet of gas made is quite constant for different rates of blast and make, within the limits of efficient control of heats.

William E. McKay, General Manager,
New England Gas & Coke Co., Boston.

Question No. 60.

What efficient benzol vaporizer is there on the market capable of enriching 100,000 cubic feet of ordinary coal gas per hour two candles?

Answer.

So far as we know there is at the present time no manufacturer of gas works apparatus who advertises benzol vapor-

izers. By making use of the sketch shown on page 118, Proceedings of the American Gas Institute for 1909, any shop can easily make the apparatus required. The paragraph describing this apparatus states that approximately four gallons of benzol per hour can be vaporized per square foot of heating surface. To enrich 100,000 cubic feet of gas two candles would require from 7 to 10 gallons of benzol per hour. Three feet of heating surface in the vaporizer would therefore be ample to do the work.

WARREN S. BLAUVELT, Engineer Coke Oven Dept.
Solvay Process Co., Detroit.

QUESTION No. 61.

What is the best accepted method of checking Orsat analysis results?

ANSWER.

The simplest and most conclusive check is to run a duplicate sample on a Hempel apparatus for exact gas analysis. An Orsat apparatus is not adapted to very accurate work. Error is due to the form of the apparatus, difficulties of manipulation, and the trying circumstances under which it is used.

F. E. PARK, Supt.,
Detroit City Gas Company.

QUESTION No. 62.

(A) What is the easiest method of checking the carbon oxide elements of a gas against a total which is about 34½ per cent.?

$$(X \times CO + Y \times CO_2 = 34.5\%)$$

(B) What values should be given X and Y?

ANSWER.

In general, a formula based on the CO and CO_2 content of a flue or producer gas is of little value in checking the analysis for accuracy. So many disturbing factors enter into a problem of this kind that is is impossible to develop a formula that shall be generally applicable.

In producer or flue gas there may exist three general types of combustible gases, more or less completely burned:

1. Straight producer gas, the product of incomplete combustion of dry air and dry carbon.

2. Blue water gas from the moisture in the air and fuel.

3. Coal gas, from the volatile part of the fuel.

If the last two types are absent, an analysis may be easily checked from consideration of the composition of the pure unburned producer gas:

$$\underset{(1\text{ vol.})}{2C} + O_2 = \underset{(2\text{ vols.})}{2CO}$$

The 20.8 per cent. of oxygen in the air doubles in volume in forming carbon monoxide. Hence pure unburned producer gas has 34.44 per cent. CO:

$$100\left(\frac{2 \times 20.8}{120.8}\right) = 34.44 \text{ per cent.}$$

Then, if the burned gas and excess air are eliminated from calculation, the analysis may be considered accurate in the degree in which the CO content of the remaining pure producer gas approaches 34.4 per cent.

If no CO is present the CO_2 and O_2 should, of course, be 20.8 per cent.

It is the last two types of gas,—the blue water gas formed from the moisture in the fuel and air, and the coal gas formed from the volatile part of the coal,—which introduce variables, interfering with the operation of any formula that might be devised. It is evident that the amount of burned or unburned coal gas coming from the volatile part of the fuel cannot be determined by analysis and its effect on the analysis estimated since coal gas is variable in composition and the water formed in combustion condenses out. Therefore, the only possibility of checking an analysis depends upon the assumption that the amount of volatile matter in the fuel is too low to have any appreciable effect.

The second disturbing factor, the formation of blue water gas, could be allowed for if it were not for the impossibility of knowing at what temperature the reactions take place.

Moisture reacts with incandescent carbon as follows depending on the temperature:—

Above 1,800° F.

$$H_2O + C = H_2 + CO$$

Below 1,800° F.

$$2H_2O + C = 2H_2 + CO_2$$

Eighteen hundred degrees F. is about the temperature at which carbon dioxide is appreciably decomposed by incandescent carbon. As there is no way of telling in what proportion these reactions take place, an analysis showing hydrogen cannot be checked.

In case no hydrogen is found the problem is greatly simplified, since no permanent effect can be caused by decomposition of water if the hydrogen is burned back to water again before the analysis is taken. The water acts simply as a carrier of oxygen, and the resulting gas is identical with the products of combustion of dry carbon and dry air.

A formula for checking the analysis of gas from the combustion of dry carbon and dry air would then be applicable to any flue or producer gas, providing no hydrogen were found in the analysis, and that the amount of volatile matter in the fuel were inappreciable. If dry carbon is burned with dry air the following equations take place, considering the combustion to take place in two stages:

(1) $$2C + O_2 = 2CO$$

(1 vol.) (2 vols.)

(2) $$2CO + O_2 = 2CO_2$$

(2 vols. + 1 vol. = 2 vols.)

If just sufficient air is admitted to form CO, the resulting gas will contain 34.44 per cent. CO, as previously noted. Equation (2) shows that there is no change in volume of the carbon oxide when CO burns to CO_2. Every volume of CO forms an equal volume of CO_2 but the oxygen disappears. Hence the per cent. of the carbon oxides would remain constant on burning, without excess of air, if it were not for the dilution with nitrogen.

For every volume of CO burned, half a volume of oxygen disappears (equation 2) and the resulting gas is diluted with $\frac{3.808}{2} = 1.904$ nitrogen and oxygen in the air:

$$\frac{79.2}{20.8} = 3.808.$$

As every volume of CO burned is represented by an equal volume of CO_2, every per cent. of CO_2 represents 1.904 per cent. of nitrogen of "dilution." Subtracting 1.904 per cent. for every percent CO_2, from the original volume considered in figuring the analysis, the per cent. of combined oxides will remain constant at 34.44 per cent., if the analysis is correct.

Let x=per cent. CO, y=per cent. CO_2, and z=per cent. O_2,—

then $\frac{x + y}{(1-0.01904\,y)(1-0.04808\,z)} = 34.44$ per cent.

(4.808 = ratio of air to oxygen in the air):

$$\frac{100}{20.8} = 4.808.$$

The second factor below the line eliminates excess air from the calculation.

The following analysis given in Mr. Chas. D. Lamson's Paper on "A Pound of Coal" (American Gas Light Journal, page 341, 1910; Progressive Age, April 15th, 1910, page 329; Proceedings American Gas Institute, Vol. 4, page 352) illustrates the operation of the formula:

Oxide Fluc.

	Per cent.
CO_2	10.0
O_2	0.4
CO	18.7
N_2	70.9
	100.0

$$\frac{18.7 + 10}{(1 - 0.01904 \times 10)\ (1 - 0.04808 \times 0.4)} = 36.14 \text{ per cent.}$$

instead of the theoretical 34.44 per cent.

A producer gas analysis in the same paper gives the following result:—

	Per cent.
CO_2	3.7
O_2	0.0
CO	28.5
N_2	67.8
	100.0

$$\frac{28.5 + 3.7}{(1 - 0.01904 \times 3.7)\ (1 - 0.04808 \times 0)} = 34.6 \text{ per cent.}$$

These analyses were both made with an Orsat apparatus, from coke fires.

F. E. Park, Supt.,
Detroit City Gas Company.

Addendum to Answer to Question No. 62

Under no circumstances is there a gas producer or water gas machine working with absolutely dry air or with pure dry carbon. A very small quantity of any gases containing hydrocarbons would vitiate results based on pure carbon. In practice it would be found exceptional for the above formula to be of any practical value.

Bureau of Information.

Question No. 63.

(A) Has there been any litigation against the erection of Gas Holders? If so, cite cases and nature of cases.

(B) Are there any statistics on explosions of Gas Holders?

(C) Has a Gas Holder ever been struck by lightning such as to seriously damage same and cause an explosion?

(D) Is there an authenticated compilation of the number of Gas Holders in use in the United States? How long have they been used and how many have exploded, if any?

Answer.

(A) There has been considerable litigation in connection with Gas Holders. City of Cleveland vs. Gas Light Company,

No. 20, New Jersey, *e. q.*, 201. Court held that a Gas Holder in itself was not a nuisance. Brooklyn Union Gas Company had a suit brought against it enjoining them from building a Gas Holder in the neighborhood of a hospital. Decision favorable to Gas Company was rendered by the Appellate Division of the United States Court.

(B) There is no compilation of statistics on explosions of Gas Holders. So far as we can learn there has been no real explosion of a Gas Holder. Gas Holders have collapsed and afterwards taken fire.

(C) No information has been obtained.

(D) No information on this point has been obtained.

BUREAU OF INFORMATION.

QUESTION No. 64.

What book would be of the most value to a man who is beginning the study of the manufacture of gas?

ANSWER.

"Catechism of Central Station Gas Engineering in the United States."

Published by the Trustees Gas Educational Fund, No. 58 Williams Street, New York.

BUREAU OF INFORMATION.

QUESTION No. 65.

Under ordinary conditions, does increasing the yield of gas per ton of coal carbonized decrease the candle-power?

ANSWER.

A categorical answer to this question cannot be given. If an increased yield of gas is obtained by introducing dilutents such as furnace gases or air, then the candle-power would be decreased much faster proportionately than the make of gas increases. If the increased yield is obtained by operating the retorts under a reduced constant pressure such as is possible with a first-class retort house governor, then the candle-power will remain nearly constant and the B. t. u's will be

slightly reduced. If it were possible to maintain zero pressure in the retorts, the yield would be at the maximum, the candle-power slightly under the maximum, and the B. t. u's reduced about 2 per cent.

If the yield of gas were increased by lengthening the period of carbonization, thereby reducing the percentage of volatile matter in the coke (the additional gas being almost entirely hydrogen) then both the candle-power and the B. t. u's would be reduced. The increased yields due to higher heats result usually in a lower candle-power and B. t. u's. There will be some variation in this, however, dependent upon the kind of coal used.

In coke oven operation it has been found in practice that the yield of gas can be increased with no effect upon the candle-power by running the oven at a more uniform pressure throughout the entire coking period.

V. F. Dewey, Engineer,
Detroit City Gas Company.

Answer-at-Large.

It is, of course, self-evident that if all other conditions remain the same, increasing the yield of gas per ton of coal carbonized would decrease the candle-power but nobody can say definitely what difference in yield would be expected in lowering the candle-power from 18 to 16. It will be necessary to know to even make an approximate guess whether the candle-power is measured in an Argand burner or open flame.

If the time of carbonization remains the same and the yield is increased by increasing the temperature of the retort, the increased temperature itself would tend to reduce the candle-power and thus introduce a disturbing element. If the yield should be increased by reducing the charge with the time the same, or by increasing the time of carbonization with the same weight of coal, different results might be expected in each case. The kind of coal used, the size of retort and the method of charging would also have an influence, so that in my

opinion the only way that the question can be answered is by the making of actual experiment by the Works desiring information.

I might venture as a guess that if the candle-power is measured on the open flame the product of the yield by the candle-power or the candle-feet would be very nearly the same with 16 candle-power gas as with 18 candle-power gas. If the candle-power is measured in an Argand burner I would expect a small increase in the candle feet.

E. H. Earnshaw, Ass't Gen'l Mg'r,
Public Service Gas Co., Newark, N. J.

Question No. 66.

Present plant conditions: making 125,000 cubic feet coal gas per 24 hours.

Holder capacity: 60,000 cubic feet.

Contemplate putting in a small water gas set to make 20 candle-power carburetted water gas to mix with coal gas.

What effect will the mixing of water gas under the above conditions have on the mantle burners throughout the town?

Answer.

The effect of mixing water gas of 20 candle-power with coal gas, under the condition stated, would not be noticeable in the mantle burners of the city—providing the percentage of water gas did not exceed say 50 per cent. Above this percentage a slight adjustment of the burners would probably be necessary in order to secure best efficiency and to prevent striking back of the flame into the mixer. This would be due to the change in specific gravity of the gas. Approximately the same quantity of air would be required for combustion of 16 candle-power coal gas and a 20 candle-power water gas, and with an admixture of water gas such as the question evidently presupposes, I do not think the average consumer would notice the change.

H. Russell, Supt.,
Rochester Railway & Light Co., Rochester, New York.

Question No. 67.

What has been done or is being done in the way of automatic shaking grates for water gas generators?

Answer.

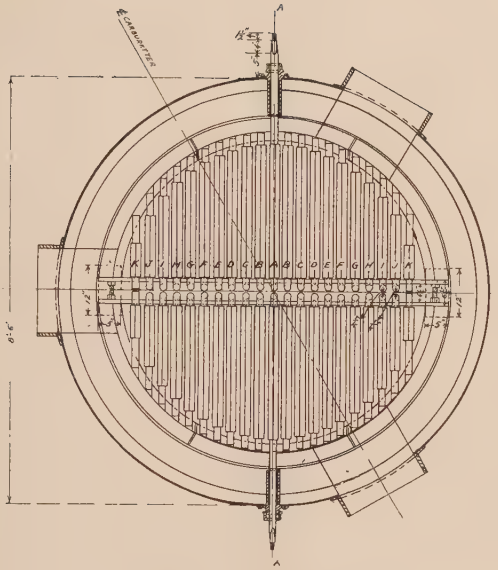
The shaking grate described below is in operation at Denver, Colorado. Definite data have not as yet been obtained as to its effect on the operation of a water gas machine. Mechanically the apparatus works well.

This grate is adapted for use in any ordinary generator, without disturbing the lining except at the grate level.

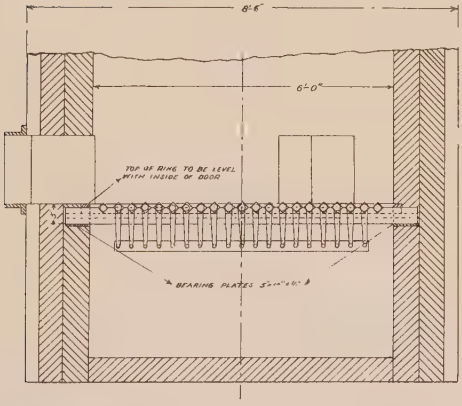
The flat bearing ring of the ordinary grate is replaced by a special cast ring grooved on top, for holding in place the rounded ends of the grate bars. These grooves are of sufficient depth to prevent the jumping of the grates during the shaking operation, and are spaced about three inches centers when used with 1¾ inch square bars set on edge.

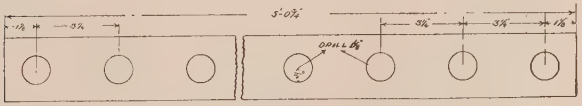
The center support consists of two separate supporting bars having a clearance of about four inches between them, and extend into the linings on either side, resting on cast iron bearing plates. This double center support divides the grate area into two equal parts, each of which are shaken separately. The grate bars themselves are inch and three-quarter square wrought bars, one end of which are forged round to fit loosely into the grooves of the bearing ring. The other ends are also forged round to fit loosely into the grooves of the center support. At the inside of this supporting bar the grate bar bends down at right angles into the space between the two supports, forming a tapering crank arm about 9 inches long, terminating in a cylindrical nub, one inch in diameter, and two inches long, bent back in a line parallel with the grate itself.

After the grate bars are in position, the bars are all connected together by a strap of 1¾x2½ inch iron, drilled with holes to fit the nubs, and secured by cotter pins. This arrangement connects together all of the bars of the half set in such a manner that when one bar moves, its movement is

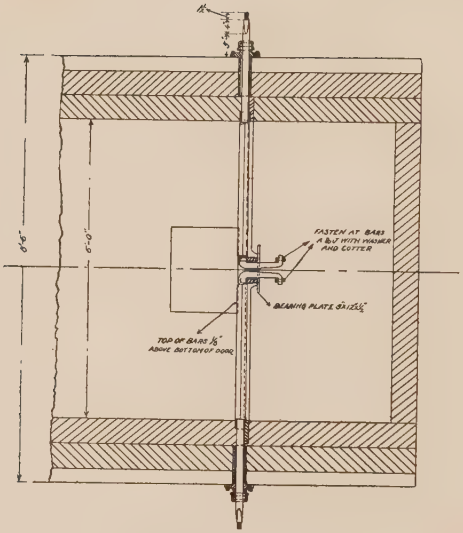


ASSEMBLY
SHAKING GRATES FOR WATER GAS GENERATOR
PLAN

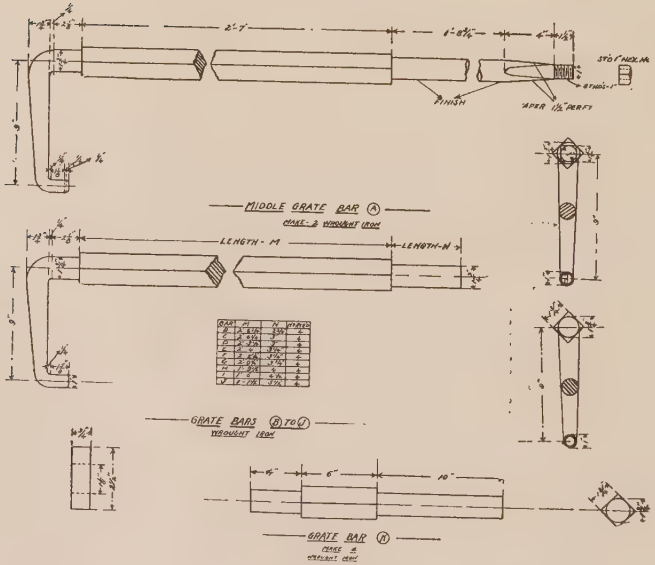


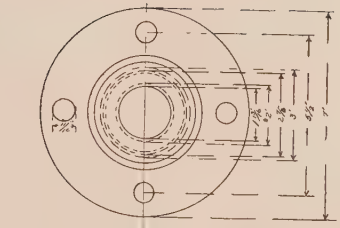


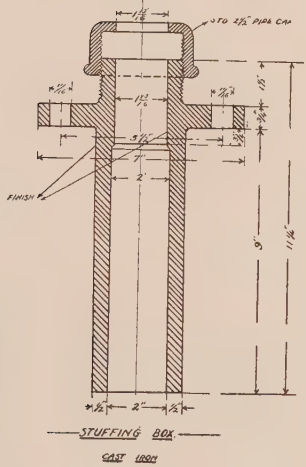
CONNECTING LINK
MALLEABLE IRON



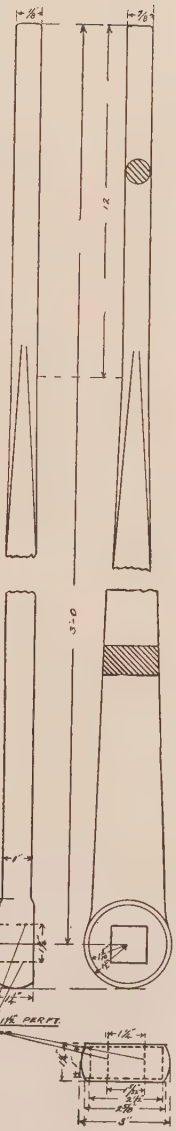
SECTION AT A-A







STUFFING BOX
CAST IRON



SHAKING LEVER
WROUGHT IRON

communicated through the strap to all other bars in the set.

The center grate bar of the half set is made long enough to extend through a stuffing box to the outside of the shell, and terminates in a squared shank. This bar can now be rocked by means of a lever and in rocking moves every bar of the entire half grate. The other half set is fitted up in the same manner. (See drawing.)

A. F. Traver, Supt. Gas Dept.
Denver Gas & Electric Co.

Question No. 68.

What information is there concerning the operation of coal gas retort benches in connection with a non-coking coal of high volatile? Has such a thing ever been attempted and if so, what disposition was made of the solid residual remaining in the retorts after volatilization? Has an attempt ever been made to burn this residual in the furnaces under the benches? If so, just how was it manipulated, and was it necessary to add a certain portion of green coal?

Answer.

The Bureau of Information submits the following letter as an answer to Question No. 68:—

Mr. V. F. Dewey,
Detroit City Gas Company,
Detroit, Mich.

Dear Sir:—Referring to your letter of Aug. 4th enclosing question No. 68 which has been submitted to the Bureau of Information, American Gas Institute.

Some years ago we used Cannel Coal at our plants, but used a very small percentage which we disposed of as fuel under the boilers. The Cannel Coal used, produced about 50 per cent. of its weight of coke and this was charged to the boilers at the rate of two-thirds of the cost of the regular boiler fuel.

It is impossible to use this coke in the bench furnaces in any

large proportions mixed with coal or good coke without affecting the heats considerably.

Yours truly,

W. H. Barthold,

Consulting Gas Engineer,

Hodenpyl, Walbridge & Co.

Question No. 69.

What is the best practice in velocity of gas permissible through, first, water gas set; second, oil gas set; third, coal gas works (in the above is meant velocity of gas through the connections and piping connecting the various units); fourth water gas scrubbers of the spray brick variety; fifth, purifying boxes; sixth, through gas works or connections; seventh, through multitubular condensers?

Answer.

The main objects in designing the connections through a water gas set is to avoid congestion and consequent back pressure of the gas as far as possible consistent with preserving the integrity of the units. In modern practice the velocity is from 3,000 to 4,000 feet of gas per minute during gas making time, the volume being computed at the existing temperature at which it passes through the connections.

In oil gas practice this velocity is reduced to 2,000 to 2,500 feet per minute.

Coal gas practice would indicate the velocities at the different connections as follows:—

Inlet primary condenser, 150° F., 700 feet per minute.
Inlet water tube condenser 120° F., 550 feet per minute.
Inlet scrubber ..... 85° F., 475 feet per minute.
Outlet scrubber ..... 75° F., 460 feet per minute.

In water gas scrubbers, assuming 50 per cent. of shell area available for gas passage and an average temperature of 200°, the velocity is about 16½ feet per minute of actual gas making time.

The accepted best practice regarding velocity of gas through purifiers is 1/5 inch to 1/4 inch per second, or 60 to 75 feet per hour, calculating the purifiers as empty vessels.

The average velocity of coal gas through the gas works connections is about 450 feet per minute at 60° F.

So many factors enter into multitubular condensers that a great variety of answers could be given to the question, but ordinarily a speed of 30 feet per minute can be safely assumed.

Question No. 70.

In considering an equation relative to the operation of water gas machines, if A equals the total cubic feet of air under the grate bars for any given number of blasts and S equals the lbs. of steam passing through the fuel bed for an equivalent number of runs, what should be the value of the constant X in the equation:

$$X = \frac{A}{S},$$

in each of the following conditions: size of machine 6 feet, size of machine 8 feet, size of machine 10 feet, size of machine 12 feet; kind of fuel, hard coal; kind of fuel, oven coke; kind of fuel, gas coke?

Answer.

In reply to the inquiry as to the proper quantities of air and steam to be supplied to generators per M feet of carburetted water gas made, we would say the following:—

This question cannot be answered, because X in the equation is not a constant. The length of run, candle-power requirements, relative cost of coal and oil, temperature of in-coming air, and the degree of humidity in the air would make it a variable. I do not believe that a water gas apparatus will ever be surrounded by conditions that will make it possible to answer this question with accuracy for each of the conditions enumerated.

The quantity of air required will, of course, vary some-

what according to the condition of the fuel, whatever its kind; if, for instance, it contains a large percentage of moisture, or is of very large and irregular size, the air supply demanded will probably be somewhat greater than under opposite conditions. It seems, from good practice, that with clean and reasonably dry fuel the quantity of air required per M of 22 candle-power will be about 1,400 cubic feet. It should not differ from this figure very greatly for either of the three fuels mentioned,—gas coke, oven coke, or anthracite coal.

The quantity of steam required per M will vary slightly, according to size, etc., of the fuel. From 28 to 30 lbs. per M should suffice for a good grade of any of the three foregoing kinds of fuel.

As to the effect of size of set, it seems likely that the air and steam supply required should be slightly greater with small than large sets. Examples of good practice show, however, that under above mentioned good conditions, the air and steam supply required should be but little greater for small than for large sets.

W. H. Gartley, Engineer,
United Gas Improvement Co., Philadelphia.

Progress Department.

The President called for the report of this department and the same was read by Capt. W. E. McKay as follows:—

PROGRESS DEPARTMENT.

Mr. Butterworth's report at Detroit, in 1909, was a comprehensive and exhaustive survey. In the interim there have been published supplementary partial reviews at the meetings of the State Associations.

For this present meeting of the Institute there have been contributed many and excellent papers, further descriptive, in detail, of technical advance.

Therefore your Editor respectfully reports progress.

William E. McKay, Editor.

The President: Gentlemen, you have listened to the reading of this report and if there is no objection it will be accepted and placed on file.

Report of the Trustees of the Gas Educational Fund

The President called for this report.

Mr. A. E. Forstall, Secretary of the Trustees made the following preliminary remarks:—

Mr. A. E. Forstall: Mr. President and gentlemen, as the report has been printed and distributed to members, I will not read it in full. There are one or two points, however, to which I wish to call special attention. The first of these is that after quite a little delay, due to one cause and another, the questions, and answers issued to the questions, have finally been published in book form and the book was issued in January of this year. The trustees are sorry to have to report that, in spite of advertising and circulars sent to every member whose name appeared as a member of any gas association in the United States—they have not as yet succeeded in selling enough books to pay for the cost of the publication. I would also call attention to the progress which has been made in the matter of investigating the career of the graduates of the class. It is very gratifying to find that over one-third of these graduates had secured decided promotion in the years since they entered the class. The only other point to which I wish to call attention is the fact that the finances of the trustees have been so economically administered, without allowing the work to suffer, that at present they have built up a surplus fund of $13,640, which is almost all invested in good securities that pay a very fair rate of return. One great desire of the trustees is that this surplus fund should be built up to proportions so substantial that the income from it will practically carry on the work without making it necessary to drum up subscriptions each year.

The report of the committee in full is as follows:—

TWELFTH ANNUAL REPORT OF THE TRUSTEES GAS EDUCATIONAL FUND TO THE SUBSCRIBERS TO THE FUND.

To the Subscribers to the Trustees Gas Educational Fund:

GENTLEMEN:—The Trustees appointed at the Twenty-sixth Annual Meeting of the American Gas Light Association, held October 17, 1898, to administer the Educational Fund formed by your subscriptions, submit the following report as to the work done from October 1, 1909, to September 30, 1910.

The Treasurer's Report shows that there has been a small surplus of income over expenses in place of the comparatively large deficit of the preceding year. This change from a deficit to a surplus is largely due to the renewal of a number of one year subscriptions, only one-fifth of which had been counted applicable to the income of the previous year, rather than to the obtaining of entirely new subscriptions. Only a few of these were obtained for the current fund and none were secured for surplus fund.

The publication, under the title "Catechism of Central Station Gas Engineering in the United States," of the book containing all the answers sent out to the different sections of the class was completed in the latter part of December, 1909, and the copies for which advanced orders had been received were sent out early in January, 1910. This publication has been advertised in the Gas Journals and Engineering News, and also by more than two thousand circulars mailed to all the gas men whose names were found on the membership lists of the different gas associations in the United States. This advertising has resulted in the sale, up to, but not including, October 1st of five hundred and twenty-eight copies. Up to the same date there had been presented to the libraries of the gas and other engineering associations and to subscribers of more than $50 per year, forty-seven copies. The total number of copies bound was one thousand, so that four hundred and twenty-five are still on hand and for sale. As shown by the Treasurer's Report, the sales up to October 1st amount to $81 less than the expenses of publication and advertising.

A study of the information on hand as to the positions held by graduates of the class, both when they made application for admission and at the latest date covered by the information, shows the following facts:

Excluding the sections of 1909 and 1910, the last two to graduate, as having had too short a time to show the effects of the course, there has been a total number of one hundred and twenty-seven graduates, of whom one hundred and twenty-five are living. Information is at hand as to the positions held, either at the present time or only a short while ago, by seventy-eight. Seventy-five are still in the gas business, and forty-nine of these, belonging to eight sections, have obtained decided promotion, such as from the positions of clerk in the office or at the works, canvasser, store-room keeper, or draftsman, to those of superintendent of distribution or superintendent, engineer, manager or general agent of a gas company or the gas department of a combined company. An attempt is being made to obtain information as to the present positions of the forty-seven graduates about whom this information is lacking, but even if none of them have obtained decided promotion and show only the slight promotion, or greater efficiency in their original position, of the remaining twenty-six whose status is known, the record fully warrants the existence of the class in the past and its continuance in the future.

During the year twenty-one members of the Section of 1910 finished their course and their connection with the class ceased, while the Section of 1912 started work on January 1, 1910, with a membership of forty-seven.

The number of members in each section at the beginning of the year, the changes that have taken place during the year, and the names of the members of the class who have completed the course during the year, are shown in detail on the Secretary's Report which is appended.

The Section of 1911 now contains twenty-one members, the Section of 1912 twenty, and the Section of 1913 forty-one, making the total membership in the regular class eighty-two.

Two special students are receiving the questions and answers with the Section of 1912 and one special student is receiving the questions and answers with the Section of 1913.

The card index of the principal articles published in the American Gas Light Journal, Progressive Age, and the Journal of Gas Lighting has been kept up during the year.

It may be advisable to remind the subscribers that at the office of the Secretary, No. 58 William Street, there is a room conveniently located in the downtown business district which is available for their use in case when visiting New York they wish to arrange for meeting friends or business associates at some place other than their hotel.

The Treasurer's Report, which is appended, shows the total amount of subscriptions to date, the available income and expenses for the year, summary of the cash account and the statement of the amount of surplus fund and the securities in which it has been invested.

The Surplus Fund, now amounting to $13,640.16, is made up of a contribution of $2,000, of subscriptions paid in advance of the time when they were due, of unexpended balances and of interest received on investments. The proper portion of the advance subscriptions will, of course, be drawn out each year to meet expenses, but the unexpended balances and the interest will accumulate into a fund which will be available to assist in carrying on the work in case all the present subscriptions are not renewed when they expire.

Respectfully submitted,

Trustees Gas Educational Fund,

Walton Clark,
Chairman.

Alfred E. Forstall,
Secretary.

SECRETARY'S REPORT, SEPT. 30, 1910.

	Section of 1910	Section of 1911	Section of 1912	Section of 1913	Special section 1912	Special section 1913	Total
Members enrolled Oct. 1, 1909...	23	29	51		5		108
Entered Class Jan. 1, 1910				47			47
Additions to Class since Jan. 1, 1910				36		1	37
Reinstated since Oct. 1, 1909..		1					1
	23	30	51	83	5	1	193
Resigned since Oct. 1, 1909...			6	5	3		14
Dropped for non-receipt of answers since Oct. 1, 1909	2	9	25	37			73
Finished course during year ...	21						21
	23	9	31	42	3		108
Total enrollment Sept. 30, 1910.		21	20	41	2	1	85

Applications on file for admission to Class Jan. 1, 1911.. 17

NAMES OF STUDENTS WHO COMPLETED THE THREE YEARS' COURSE WITH SECTION OF 1910.

H. S. BRAMWELL, Lincoln, Ill.
WILLIAM J. CALLANAN, Seneca Falls, N. Y.
RALPH S. CARTER, Malden, Mass.
F. J. COX, Philadelphia, Pa
EDGAR B. DAVIS, Mount Vernon, N. Y.

F. A. Gallagher, Jr., Providence, R. I.
E. M. Garrett, Denver, Colo.
S. A. Goodman, Harrisburg, Pa.
Chas. A. Grange, Philadelphia, Pa.
J. W. Green, Mount Vernon, N. Y.
E. B. Guenther, Pittsburg, Pa.
A. A. McLearn, Wilkinsburg, Pa.
J. M. Morris, Omaha, Neb.
W. B. Noffsinger, Terre Haute, Ind.
A. R. Ritchie, New York, N. Y.
Américo Rodriguez, Havana, Cuba.
G. Warren Stiles, Fitchburg, Mass.
Thos. B. Tinney, Philadelphia, Pa.
Geo. W. Wallace, St. Louis, Mo.
F. S. Williams, New Haven, Conn.
Carl B. Wyckoff, Mobile, Ala.

Report of Wm. R. Beal, Treasurer, for the Fiscal Year Ending Sept. 30, 1910.

Condition of Subscriptions.

		For year 1909-1910
Total old subscriptions holding over from second five-year period.....	$ 409.00	$ 266.00
Total new subscriptions for third five-year period Sept. 30, 1909.....	17,540.00	3,283.00
Subscriptions received since that date.	2,915.00	583.00
	$20,864.00	$4,132.00
Received from subscribers since Sept. 30, 1909	$ 5,922.00	
Payments not applicable to year	3,327.00	
Total paid in by subscribers since Sept. 30, 1909, and available for year..	$ 2,595.00	
Paid in previous to current year on account of 1909-1910 subscriptions..	1,467.00	

Total paid in by subscribers available for this year	$ 4,062.00	
Still to be paid for this year	70.00	
Total subscriptions for year		$4,132.00
Dues received for membership in Special Class		5.00
Total amount available for year		$4,137.00

Statement of Income and Expense.

Total amount available for year		$4,137.00

Expenses.

Secretary's Salary	$ 3,000.00	
Office Rent	300.00	
Printing, Stationery, Postage, etc.	706.44	
Periodicals and Binding	14.75	
Fire Insurance on Books	17.01	
Total expenses for year		4,038.20
Balance		$98.80
Depreciation on Furniture		14.05
Total balance on year's operation		$84.75

Cash Account.

Received from subscribers since Sept. 30, 1909, Current Fund	$ 5,922.00	
Interest on securities owned as scheduled under heading "Surplus Fund"	360.00	
Interest on deposits in bank	115.06	
Dues received for membership in Special Class	5.00	
Received for copies of "Catechism of Central Station Gas Engineering," including carrying charges	2,679.55	

Total receipts for year	$ 9,081.61	
Cash balance from last year	4,226.46	
Total to account for		$13,308.07
Expenses for year paid	$ 4,038.20	
Syracuse Light & Power Co., Collateral Trust Sinking Fund 5% Bonds	3,831,25	
Expense of Publication of Catechism	2,947.73	
Total paid out		10.817.18
Balance		$2,490.89
Balance in Knickerbocker Trust Co., as per Pass Book	$ 386.87	
Balance in Guaranty Trust Co. of New York, as per Statement, less checks unpaid	1,984.02	
Cash on hand		2,490.89

Publication Account.

Balance from 1908-1909	$ 5.57	
Received for copies of "Catechism of Central Station Gas Engineering in the United States," including carrying charges	2,679.55	
	$ 2,685.12	
Due for books delivered but not paid for	181.26	
		$ 2,866.38

Expenses.

For publication of "Catechism of Central Station Gas Engineering"	$ 2,673.39	
For Copyright	6.70	
Postage, Expressage and Stationery	197.64	
Advertising	37.00	
Circulars	33.00	
		2,947.73
Deficit		$81.35

Surplus Fund and Investment.

Amount paid in by subscribers in advance	$ 4,148.00	
Amount paid in by subscribers to Surplus Fund	2,000.00	
Unexpended balances previously reported (after deduction of amount, $165, of subscriptions previously reported but cancelled later; see minutes of meeting Oct. 8, 1908, Dec. 9, 1909, and May 12, 1910,	4,879.90	
Interest on bonds to date	2,617,22	
Interest on deposits in bank	493.31	
	$14,138.43	
Less amount of deficit for year 1908-9	498.27	
		$13,640.16

Already Invested.

$2,000 Binghamton Gas Works, 1st Mtg. 5% Bonds	$ 1,930.00	
$1,500 Atchison, Topeka & Santa Fe R. R. General Mortgage 4% Bonds	1,513.75	
$2,000 Omaha Gas Co. 1st Mtg. 5% Bonds	2,000.00	
$1,500 New Gas Light Co. of Janesville 1st Mtg. Bonds (guaranteed by The United Gas Improvement Co.).	1,500.00	
$5,000 Syracuse Light & Power Co. Collateral Trust Sinking Fund 5% Bonds	3,831.25	
Furniture	126.41	
		10,901.41
		$2,738.75

New York, Oct. 13, 1910.

We, the undersigned members of the Finance Committee of the Trustees Gas Educational Fund, have this day examined the books and accounts of William R. Beal, Treasurer, for the year ending September 30, 1910, and have found the same to be correct, and the above balance of $2,490.89 to be on hand.

ALEX C. HUMPHREYS,
W. F. DOUTHIRT,
Finance Committee.

THE PRESIDENT: Gentlemen, you have listened to the report of the Trustees of the Gas Institutional Fund. It is very gratifying to hear that the Trustees have accumulated a surplus, but it is not to be considered that they do not want any more subscriptions.

If there is no objection this report will be accepted and placed on file.

I have here a telegram from the Pacific Coast which I will read.

Oakland, Calif.

American Gas Institute.

In Convention Assembled.

Greetings:

The Pacific Coast Gas Association and all California invite and urge you to accept our invitation to meet in San Francisco during the Panama Pacific Exposition, 1915. National Commercial, Canadian, South Western, Southern and North Western Associations will be invited to hold sessions and make this the greatest congress of Gas men ever convened. Best wishes for the success of your meeting.

FRANK A. LEACH, President.
JNO. A. BRITTON, Secretary.

We shall have time enough to take that up later.

We will take up now the

REPORT OF THE COMMITTEE ON CAST IRON PIPE STANDARDS.

MR. WILLIAM CULLEN MORRIS: The Chairman of this Committee asked me to request that the report be laid over until the later session, as they have received certain information which may effect their report.

THE PRESIDENT: If there is no objection, gentlemen, it will be laid over until a more convenient time for the committee.

The next thing is the report of the

COMMITTEE ON THE BEAL MEDAL.

Dr. A. C. Humphreys, Chairman.

I find that Dr. Humphreys is absent, but will return at two o'clock, so we will postpone this report until this afternoon.

The next thing in order will be a paper on

MANUFACTURE OF BALLOON GAS IN WATER GAS APPARATUS.

Mr. Waring then read his paper as follows:

MANUFACTURE OF BALLOON GAS IN WATER GAS APPARATUS.

During the past three years there has been a great revival of interest in the navigation of the air while ballooning has taken its place as a recognized sport. This has resulted in an increasing demand for gas of high lifting power suitable for balloon inflation.

An inquiry for such a gas was made of the writer in Omaha early in the present year, and this paper is the result of his attempt to supply it.

Coal Gas, when available, has been generally used for this purpose, otherwise recourse is had to the employment of chemically prepared hydrogen from small temporary plants, but this is, of course, quite expensive.

The regulations of the International Association of Aeronauts

require that the coal gas shall have a lifting power of at least 43.6 lb. and the hydrogen 65.4 lb. per M, corresponding to gravities of 0.43 and 0.15 respectively.

Apparently a gravity of about 0.33 is considered best adapted to balloon use, owing probably, to the greater loss by diffusion through the fabric with lighter gases.

In the writer's case, no coal gas apparatus was available, so that it was necessary to substitute a special gas made in water gas apparatus. After considerable investigation no promising existing methods were found, and one had to be devised; the result of this effort was the development of the process described in the following.

The method consists in largely decomposing a hydrocarbon into its elements, carbon and hydrogen, in the fuel bed of the generator of a water gas set, and completing the reaction to any desired degree in the highly heated carburetter and superheater. This process was suggested by results obtained by the writer in some earlier work,—described in a paper presented to the Western Gas Association in 1906 on the "Utilization of Tar in Water Gas Apparatus"—where it was found that by the use of a small amount of tar during the down run with steam the percentage of hydrogen in the blue gas was increased from 50 per cent. to 60 per cent., while the gravity was lowered from 0.554 too 0.456. From this data it was evident that practically any desired gravity could be obtained by increasing the amount of hydrocarbon to be decomposed and decreasing the amount of steam used.

The final tests were made with a standard six foot set of four feet internal diameter. The oil was introduced at the top of the generator with a spray to secure uniform distribution over the fuel bed. The following general conditions were found to yield successful results.

The fire should be carried low and just sufficient steam used during the blow to prevent the grate bars from burning and keep down the clinker.

The fire should be kept open by a double length blow once an hour, and by lightly breaking up with a bar twice a day.

The first half of the run is made "Down" without steam. From 15 per cent. to 20 per cent. of the oil is admitted before closing the stack valve to purge the blast gases out of the set.

The last half of the run is made "Up" using sufficient steam to bring the gravity up to the point desired.

The heats should be carried high through the whole set.

A copious supply of water should be run in the wash-box to keep the lampblack washed out.

A typical run gave the following results:—

Coke, gas, from West Virginia coal.

Total make corrected		98,000 cu. ft.
Make per hour		10,900 cu. ft.
Steam per M run		18.5 lb.
Oil per M		6.9 gals.
Coke per M		30.2 lb.
Air per M through fire		2,690 cu. ft.
Steam during blow per M air		70 lb.
Temperature at bottom of superheater		1,630° F.
Length of blow, 4 min.; length of run, 6 min.		
Depth of fire, 4 ft. to 5 ft.		
Specific gravity of gas....	Maximum,	0.390
	Minimum,	0.330
	Average,	0.350

The two analyses given below show some of the possibilities of this process. Sample "A" was taken during the latter end of the run, the results of which are given above, while sample "B" was taken during an earlier test, and shows the ease with which a very low gravity can be made if desired.

	Sample "A" Per cent.	Sample "B" Per cent.
Illuminants	1.0	0.4
Carbon monoxide	15.3	5.2
Hydrogen	63.7	75.4
Methane	11.0	10.4
Ethane	0.8	0.0
Carbon dioxide	2.6	1.0
Oxygen	0.5	0.6
Nitrogen	5.1	7.0
Specific gravity	0.37	0.25

It is very desirable that the illuminants should be kept as low as possible to prevent their injurious action on the rubberized fabric.

It is, therefore, possible to easily and efficiently manufacture a gas of any desired gravity in standard water gas apparatus that will be entirely suitable for balloon inflation and will very closely resemble a low grade of coal gas in its composition. The commercial aspects of the process will, of course, be dependent upon the possible local demand, but in time of war it might prove of considerable value.

It may be of interest to note that parties making application for a gas franchise in a certain city, stated, as a merit of their gas, that it would be suitable for balloon use. From the foregoing analyses, however, it will be seen that a gas suitable for balloon use would be one of very poor quality for public distribution.

THE PRESIDENT: Gentlemen, you have listened to a very interesting paper by Mr. Waring. As the tendency of the day seems to be to get up in the air, it is very timely. I believe Dr. Elliott is to open the discussion on this paper.

DR. A. H. ELLIOTT: Mr. Chairman, the paper is extremely interesting and opens up a new line of work with regard to heat and its action upon hydrocarbons. It is rather new to the chemist that the hydrocarbons should be so completely broken up. It is very unusual to see a gas of this kind that

has as low as one per cent. of illuminants. In the early part of the run it is only four-tenths of one per cent. Another curious characteristic of this gas is the fact that low carbon dioxide or carbonic acid is concordant with a high average, which is a little different from our water gas practice. If you will remember, in most of our results, when we get a good deal of carbonic acid gas, the hydrogen will be increased and there seems to be an advantage in that reaction. It shows a line of work that is extremely interesting. The question of the lightness of gas for the balloon is interesting too. You must not have a gas that is too light; for it will not stay in the fabric. That has been the difficulty with most of these balloon men. They have been fighting for a light gas, forgetting that every increase in the lightness means an increase in the diffusion in four times the ratio; so there is a certain limit to the specific gravity, which Mr. Waring has put at about 0.35, as the proper limit. I do not find anything to criticise in the paper, and wish to compliment the author upon the very careful record of a very interesting series of experiments in a new line of work. Of course, we all know that you can make hydrogen, if you wish, by passing steam over iron, and then getting the hydrogen out and reconverting the iron into metal by using water gas or carbon monoxide; but, as our worthy president knows, we tried that scheme a good many years ago, and while it will go along for a certain number of reactions, after a time it will not work. There apparently results a condition of the oxide of iron that makes it inert. That scheme was at one time suggested by some men in the Army for inflating Army balloons, but this method of Mr. Waring's is the most practical one I have seen described.

THE PRESIDENT: Is there any other member who would like to discuss the paper, or ask any questions of Mr. Waring? If not, Mr. Waring will close.

MR. WARING: With regard to Dr. Elliott's point the low illuminants as compared with previous experience in water gas practice, I do not think Dr. Elliott understood thorough-

ly that this hydrocarbon went through a fire bed, whereas, in the common water gas practice, the hydrocarbons are put through checker work at a very much lower temperature. If we get our checker work too highly heated or heated anywhere near the temperature of the generator, we break down our hydrocarbons to lampblack and hydrogen, and that is what takes place in going through the fire beds. These experiments were made in a very elaborate way and are very accurate.

THE PRESIDENT: I think Mr. Waring is entitled to a hearty vote of thanks for his paper.

A motion was made, seconded and carried that a hearty vote of thanks be extended to Mr. Waring, for his paper.

THE PRESIDENT: The next paper on the list is on

WASTE HEAT UTILIZATION IN WATER GAS APPARATUS.

BY MR. J. HAWLEY TAUSSIG.

Please give your attention to that. It is a very interesting subject, and I have no doubt will bring out a lively discussion.

Mr. Taussig then read his paper as follows:—

WASTE HEAT UTILIZATION IN WATER GAS APPARATUS.

The demand for further economies in the manufacturing departments of the gas business has grown more insistent during the past few years with the increasing costs of labor and materials and the tendency to lower selling prices.

In the manufacture of carbureted water gas many improvements have been made in appliances, designed to facilitate operation and to secure more uniform operating conditions. There has been but little practical effort, however, to utilize the considerable quantity of sensible heat that is known to be wasted in the off going products.

While several writers have called attention to this waste and have calculated its magnitude, and a number of theoretical discussions have appeared showing some of the economies

that might be secured by making use of this heat, yet there has been little practical work done to effect its utilization until the past few years.

In the average operation of carbureted water gas set we may expect to find the following heat quantities leaving the apparatus with the products, calculated per 1,000 cubic feet of illuminating gas made:—

In the blast products as sensible heat .	62,400 B. t. u.
In the illuminating gas	48,230 B. t. u.
	110,630 B. t. u.

This is assuming that all the carbon monoxide made in the generator in blasting can be burned and utilized in the fixing vessels. Practically, however, this is somewhat difficult, and we frequently find appreciable quantities of unburned carbon monoxide in the blast products discharged into the atmosphere. This, of course, results in a very considerable loss of fuel; thus assuming the blast products to contain 3 per cent. of carbon monoxide, we would have as latent heat of combustion about 21,800 B. t. u., or the equivalent of 1.50 lb. of carbon in the off going products. If this carbon monoxide be burned, it brings the sensible heat to a total of 132,430 B. t. u., equivalent to 9.00 lb. of carbon.

The recovery and utilization of the foregoing large quantity of waste heat is evidently a very promising field for work when we consider the time and money that have been expended in endeavoring to perfect methods of operation that will reduce the generator fuel consumption by only a few pounds at best.

Since the blast products and the illuminating gas that are leaving the set at an elevated temperature enter the apparatus as air, steam and oil at atmospheric temperature, or but slightly above it, the first thought would be to preheat them with the outgoing products, and thus prevent the loss of sensible heat from the apparatus, or at least reduce it. This phase of the subject has been discussed very fully in a paper read before

the A. G. L. Ass'n in 1891, by Mr. Rollin Norris, on "The Theoretical Effect of Preheating Blast, Steam and Oil in Water Gas Manufacture." He showed that but little may be expected from preheating the steam and oil,—slightly over half a pound of carbon utilized by each,—and there are some operating difficulties that might have to be considered, but by preheating the blast he finds promise of considerable saving. His calculations show the following saving on heating the blast to different temperatures, viz:—

Temperature of blast	500 F.	1,000 F.	1,500 F.
Saving in fuel	2.39 lb.	4.07 lb.	5.39 lb.

It will be noted that a rather high temperature is required to accomplish much of a saving. While we understand that the preheating of the blast is now in a few cases being successfully carried on at moderate temperatures, yet there are a number of practical difficulties that must be anticipated in case the temperatures were carried high enough to secure the maximum possible saving. These difficulties are the large size and initial cost of the heaters, and their high maintenance cost, unless brick filled stoves were used, which latter, however, would have to be double; larger blast openings would be necessary and very much larger blast piping, which should be fire-brick lined, increased blast pressures and more power would be necessary to force the expanded volume through the fuel bed, and the effect of a highly heated blast on the grates and on fire conditions and clinkering is somewhat uncertain. Should the temperature of the blast reach 1,200° F., which is probably the maximum practically attainable, only about 50 per cent. of the available heat would be absorbed, while the further addition of devices to preheat the steam and oil would raise this figure to about 61 per cent. It seems, therefore, when we consider the complexity of such several combined devices, their probably high aggregate cost, the care that would be required to keep them in efficient condition, that such methods would not be advisable or practical for routine operation.

On the other hand, if an additional air blast connection is made at the top of the superheater so that any carbon monoxide there present in the blast gases may be burned, and then the blast products and illuminating gas passed in turn through a properly designed boiler, we at once secure the most complete utilization of the sensible heat in the cheapest, simplest and most efficient manner. Such boiler, when properly designed may be placed in almost any position and elevated above the floor line or placed below it, and does not require any increase in the size of the building. Its operation is practically automatic and proceeds with a minimum of labor cost and a maximum of safety and efficiency. It effects a net saving of almost the entire labor and fuel cost of the same horse-power ordinary installation in the regular boiler room.

Thus, in a single cheap, compact and convenient form of apparatus we may recover the greater portion of the total available heat that has heretofore been allowed to pass off into the air or had to be removed, at considerable expense for plant, labor and water, in the condensers.

There are several features, suggested in the foregoing, in the utilization of heat with boilers, which will be taken up separately ; they are:—

Utilization of sensible and latent heat in blast gases.

Utilization of sensible and latent heat in illuminating gases.

Effect, on condensation and pumping equipment and water requirement, of cooling illuminating gases.

Labor saving.

Investment costs. Under what conditions will it pay to install boilers?

Blast Gases:

The temperature of blast gas leaving the superheater is usually between 1,300° F. and 1,400° F. In our calculations let us assume 1,300° F. With a boiler of proper design, its outlet temperature of blast gas would be about 600° F. We would, therefore, reduce the temperature 700° F.

100 × 0.083 wgt. × 0.275 sp. ht. × 700 = 1,600 B. t. u.
100 × 0.083 wgt. 0.275 sp. ht. × 700 = 1,600 B. t. u.
Or the water evaporated from and at 212° F.,—
1,600 ÷ 965 = 1.66 lbs.

In our best practice in making a 24 c-p. water gas, we use about 2,100 cu. ft. of air per M cu. ft. of gas made; discharging the same volume of blast gas at the stack. This figure, however, is only reached where the best generator fuel is used and the best results obtained, the average volume of air and of blast products being greater. The heat recovered in this case would be 2,100 × 1,600 = 33,600 B. t. u., and the evaporation from and at 212° F. will be 34.8 lbs. water per M cu. ft. of gas made. These figures would be increased by 965 B. t. u., or one pound of water evaporated, for about every 20° rise in the temperature of the gases leaving the superheater, or for every 60 cu. ft. of additional air used in blasting the set. We have obtained in actual practice with good generator fuel conditions, 38 lbs. evaporation (from and at 212° F.) from the sensible heat in the blast gases.

As before stated, the average gas works run their sets with some CO in the blast gases as they leave the superheater. In some cases this is done purposely in order to be in position to handle variable quantities of oil in the carbureter. The quantity of heat to be recovered in such case is calculated as follows:

Let us assume for instance, that there is 3 per cent. CO in the blast gases at the superheater top and this is burned before entering the boiler. If we assume that with no CO we would use 2,100 cu. ft. of air, then with 3 per cent. we would have to have about 2,175 cu. ft. of air, or 2,222 cu. ft. of products, in which there would be 66.7 cu. ft. of CO, weighing 4.93 lbs. The latent heat of combustion of 4.93 lbs. of CO would be 4.93 × 4,368 = 21,834 B. t. u. The weight of the products of combustion of 4.93 lbs. CO would be 4.93 + 12.18 lbs. air = 17.11 lbs. The heat units of these products that are not absorbed in the boiler would be,—

17.11 × 0.275 sp. ht. × 650° F. = 3,059 B. t. u.

(It is assumed that the temperature of the gases leaving the boiler will rise, with the increased temperature and volume of the inlet gases, to 650° F.)

Heat absorbed from 3 per cent. CO burned = 21,834 — 3,059 = 18,775 B. t. u. Evaporation from and at 212° F. = 18,775 ÷ 965 = 19.5 lbs.

We, therefore, can expect an evaporation of about 6¼ lbs. water (from and at 212° F.) for each 1 per cent. of CO burned.

A waste heat boiler is an efficient generator of steam, and can always be used as such, either in case of emergency or in regular operation, by making excess CO. As a rule, however, it would pay, on account of difference in price, to burn boiler fuel instead of generator fuel, but there are many cases, such as a large regular works boiler working under small load, where it would pay to burn the latter.

Illuminating Gas:

The quantity of steam made by passing illuminating gas through a boiler is greater than generally supposed. This is due to the high specific heat of the gas itself and that of the undecomposed steam which always passes through the generator fire.

In the carbureted water gas there are two variables that will affect the quantity of heat to be recovered; one, the temperature of the gas leaving the superheater, and the other the quantity of excess steam.

In our calculations, we will assume a temperature of 1,300° F., which is the same as has been assumed for the blast gases.

The quantity of steam used in the generator per M cu. ft. of gas varies considerably with the kind of fuel and other operating conditions. With no steam escaping undecomposed we would require only 16 lbs. per M; in practice, however, we seldom get much below 30 lbs. Assuming, therefore, 14 lbs. of excess steam, and a temperature of 500° F. at the boiler outlet, we would absorb from excess steam,—

14 × 0.55 sp. ht. × (1,300—500) = 6,160 B. t. u.
or an equivalent evaporation (from and at 212° F.) = 6.4 lbs.

We can thus expect to recover in evaporation 0.46 lbs. steam from every pound passing undecomposed through the generator fire.

The total weight of 1 M of a 24 c-p. water gas and tar vapor (exclusive of undecomposed steam) is about 59.5 lbs. Therefore, the heat absorbed in the boiler would be,—
59.5 lbs. × 0.49 sp. ht. × 800° = 23,320 B. t. u., or an equivalent evaporation of 24.2 lbs.

The total evaporation under the above conditions would be 24.2 + 6.4 = 30.6 lbs. There would be an additional evaporation of 1 lb. for every 33° F. rise in temperature at the outlet of the superheater. In practice, we get an evaporation of about 32 lbs. from the illuminating gas.

In the foregoing calculation no account is taken of a small further amount of heat recovered from tar condensed in the boiler.

Condensation:

The lowering of the outlet temperature of the illuminating gas by the use of a waste heat boiler has a very important effect on the subsequent condensation of the gas.

Since the highly heated gas from the take-off pipe passes over water in the wash-box, it is cooled to a considerable extent by the latent heat of the water absorbed and leaves the wash-box approximately saturated.

Knowing the initial temperature of the entering gas and water in the wash-box, we may calculate very closely the final temperature of the gas as it leaves.

Assuming inlet temperature of 500 and 1,300° F. as representing the average observed with and without a boiler, and a water temperature of 150° F., we would have outlet temperature of 183° and 165° respectively. Direct observation has given results slightly higher by a few degrees, but we believe that this is caused by the very rapid flow through the

wash-box, resulting in some of the gas passing off in a partially saturated condition. However, as far as the heat quantities are concerned, we believe the calculated temperatures to be very closely correct.

Assuming then that we will have to condense the gas to 100° F., the following data will show the effect of lowering the initial temperature by the use of the waste heat boilers, on the volume of the gas to be handled, the heat to be extracted and the water taken up in the wash-box, calculated for 1,000 cu. ft. of gas.

Inlet temp.	Outlet temp.	Volume	Water absorbed	Total heat above 100° F.	
1,300°	183° F.	2,662 cu. ft.	5.02 gal.	58,138 B.t.u.	Without
500°	165° F.	1,849 cu. ft.	1.50 gal.	27,838 B.t.u.	With
	18° F.	813 cu. ft.	3.52 gal.	30,300 B.t.u.	
Reduction of		30.5%	70%	52.2%	

While the saving in water supply to the wash-box is rather of small moment, the reduction in volume of the gas would permit the installation of 30 per cent. more gas generating capacity without increasing the size of the works connections to the relief holders, while the reduction of the total heat to be extracted in its condensers by over 50 per cent. would effect a very considerable saving in the cost of condensation, installation and pumping plant. The saving in condenser water alone in some plants where the water must be paid for, would amount to a considerable saving during the summer months especially.

Summary:

Although the minimum theoretical evaporation from both blast and illuminating gases, as calculated in the foregoing, is only 65 lbs., in a number of test of boilers utilizing both gases none gave less than 70 lbs. of water from and at 212° F. per M cu. ft. of gas. It is, therefore, conservative to assume an average evaporation of 70 lbs. per M in figuring actual saving in boiler fuel. Assuming an evaporation in works

boilers of 8 lbs. of water from and at 212° F. per lb. coal, 70 lbs. of water is equivalent to 8.75 lbs. of boiler fuel per M, which, with coal at $3.00 per net ton is worth 1.3 cents per M. Besides this, there is a saving in boiler firing, labor, etc., which we will assume 0.2 cents per M, which added to the above gives a total saving of 1.5 cents per M. This means $15.00 per million per day capacity of set, or per year, assuming a set runs 300 days, 15 × 300 = $4,500.00 saving, equivalent to $4.50 per M of daily capacity.

Although the cost of waste heat boiler installation will vary, with varying local conditions, it is conservative to estimate such an average cost at $8.00 per M per day capacity of the set. If the installation were run to its full capacity of 22 hours (exclusive of cleanings) each day for 300 days, we would save 56 per cent. of the investment in one year; if to half its capacity, 11 hours daily, 28 per cent.; or to earn 15 per cent. interest and depreciation it needs be operated only about 6 hours daily.

Where an extension is made to a plant, or a new plant erected, waste heat boilers will displace, to considerable extent, the usual works boiler plant. Such a plant would cost about $25.00 per H. P., or assuming that it requires 0.12 H. P. per M daily capacity to operate a water gas set, $3.00 per M of daily capacity. This, of course, does not include reserve boilers. It is evident that a certain amount of reserve must be provided for either the waste heat boilers or the regular works boilers, and the same reserve would be sufficient in either case. Therefore, in a new boiler plant, or an extension, we could deduct from the investment cost of the waste heat boilers this amount ($3.00) per M cu. ft. capacity per day, making our total net investment only $5.00 per M per day. Under these circumstances, the installation would be about paid for in one year.

Some of the installations in use to-day have single boilers passing both blast and illuminating gases. These boilers work successfully, but would be objectionable in residence dis-

tricts due to the evaporation of some of the tar vapors depositing on the tubes by the illuminating gas, making a yellow smoke which falls to the ground when the barometer is low. No trouble is now experienced in cleaning these boilers, although considerable was experienced in the past.

Double, or divided, boilers are, however, now being built, which will eliminate smoke nuisance entirely and still enable the heat in both blast and illuminating gases to be absorbed, the illuminating gas passing through a different set of tubes from the blast gas.

There are few progressive gas managers who would not go to the considerable trouble and expense to save, say, 6 lbs. of generator fuel, or ½ gal. of oil per M, but for some reason or other, a saving of equivalent boiler fuel does not seem to appeal to them. Why is this? The only reason the writer can see is that there are standards for oil and generator fuel efficiencies, but there is none so definite for boiler fuel. This matter is certain, however, to receive, in the future, the much greater attention which it deserves. The adoption of the methods above presented is capable of giving a boiler coal consumption of from 0 to 5 lbs. per M instead of the high quantity at present required, which is often from 10 to 20 lbs. per M.

THE PRESIDENT: Gentlemen, we have had a very interesting and valuable paper from Mr. Taussig. This is a paper that should directly interest all the manufacturers of water gas, opening up new possibilities and new ideas. I hope that there will be a full and free discussion of this paper and that a great many questions will be asked of Mr. Taussig.

MR. ROBERT M. SEARLE: In the study of a waste heat boiler for which we recently contracted considerable thought was given to its possible value to us, inasmuch as we are using gas coke direct from the retorts in the water gas apparatus. You cannot use gas coke directly in a water gas machine without an excess of CO. When you consider that boiler coal costs three dollars a ton, you can see that the increased

economy in boiler fuel, makes this waste heat boiler of even more value to us than Mr. Taussig has given it credit for. Another feature that makes it seem desirable and suggests a line of experiment would be to increase our CO. There is no reason why we should not, and it looks to me as if it was quite feasible to use a low grade of bituminous coal in the generator during the blast, getting what coal gas we can from it during the run, and burn that rich gas in the boiler, and run it to an overload capacity. That would give you a reaction efficiency both ways, on the low grade bituminous coal used in the generator in conjunction with gas coke. Mr. Taussig also states that there is no standard for boiler fuel. He speaks of saving six pounds, or one-half gallon of oil. That is just exactly where we stand, there is no standard for boiler fuel. He does not figure what the six pounds may be if taken out of a water gas machine.

The President: Surely there is some other gentleman in the room who is interested in this matter of waste heat boilers.

Mr. Waring: I should like to ask Mr. Taussig what effect, if any, it has on the tar made; if it sacrifices all the tar made, it would defeat the purpose absolutely. I understand from what he says here, that the use of a double boiler will prevent these tar vapors depositing on the tubes. I should like Mr. Taussig to bring that point out, just what the difference is between the single boiler and the double boiler in the effects on the tar made.

Mr. A. E. Forstall: I cannot quite get it through my head that the statement is correct, that you can get 30 per cent. more gas through the same size works connection, if you use a waste heat boiler than you can without it. You have not saved any of your heat, or the cost of the higher temperature at a lower specific gravity, and therefore you can put more of that gas through with the same difference in pressure. I have not had time to figure it out exactly, but it seems to me that if you had a difference of thirteen per cent., as far as my figures are accurate, in favor of the hotter

gas, you would get 13 per cent. more of the hotter gas through for the same difference in pressure than you can with the cooler gas, and that, it seems to me, should be deducted from the 30 per cent. The paper really appeals to the men who are running large works more than it does to small men like myself. In my works we only have one set. We have to fire up the boiler anyhow to get started, so it would hardly pay us to put in a waste heat boiler; but where you have sets running continuously, where you always have heat, it would seem to me, from the presentation of figures, and facts given by Mr. Taussig, that it would pay almost everyone to put in waste heat boilers.

THE PRESIDENT: Is there any further discussion, gentlemen?

MR. FREDERICK EGNER: I think this question of waste heat boilers is somewhat a local one. I speak from my own experience. We have used breeze; we are able to use it in our boilers. We use no other fuel and have some breeze to spare. In this particular instance it certainly seems a good opportunity to use the waste heat boiler.

MR. J. A. PERRY: I think that anyone who takes the trouble to figure it out will be more than convinced of the possible saving that he can make by using a boiler of this type. Some of us can probably save from one to six pounds of boiler fuel by making the necessary improvements. I expect, when my company gets ready to give me a waste heat boiler and full equipment, to be able to run my water gas apparatus without the use of any other fuel.

MR. ROLLIN NORRIS: On page 8 the table at the top, in the third column, is headed with, "Volume returned at 60 degrees temperature and thirty inches of mercury." I think that column is intended to show the volume of one thousand feet at the temperature shown in the first column. As printed I think the table is a little misleading.

MR. W. C. MORRIS: There are one or two points in this paper which are very interesting. One of them has been referred to a great many times when the subject of waste heat

boilers has come up, and that is the production of CO with the generation of steam. Normally, in the running of plants, steam is generated with, say, two dollar fuel, whereas the generator fuel will cost two to two and a half times as much. The reason given for the generation of CO in this paper is for the purpose of carbonizing or breaking up the oil. That hardly appears to be a good reason, as it is generally more difficult to maintain heat than to allow a machine to cool off. If the machine is balanced, it should not be difficult to maintain the temperature balance. One very interesting fact was brought out, and that is the excess of steam admitted into the generator, and it is a practical necessity to admit an excess; which may be recoverable energy in the form of evaporation in the waste heat boiler.

Mr. Searle: It seems to me that the waste heat boiler is particularly adapted to small works. If you start up your blast in the morning in a small works, it requires about forty minutes to get the heat up. In the small works the average fuel consumption in the boiler is anywhere from twenty to sixty pounds per thousand and a saving is very desirable.

Mr. J. J. Humphreys: The matter is not entirely new, of course, as in the old original Lowe apparatus, the water gas sets had a waste heat boiler included, and the Loomis process used waste heat boilers. The gas plant at Bergen Point in 1887 pre-heated the air for the blast and the steam, and continued it for years, but in a great many of these cases the trouble was not with the results attained when the apparatus was in good order, but with the great variation in the heats of the apparatus, which finally caused the leakage to be so great that the machine was not very economical. At Newburgh they have the Green Economizer, and I should like to hear Mr. Fields' later experience on that. Mr. Addicks, while in Boston, figured out that he could practically make all the steam he needed if he had sufficient economy, by using waste heat boilers, and he did build, I understand, some sets there. I should like to know from Mr. McKay or Mr. Addicks what the results were with those sets.

Mr. Robert E. Wyant: I should like to ask Mr. Taussig whether he finds any difference in the quantity of tar fog which is carried away with the gas after leaving the boiler, by reason of cooling the gas more slowly than is the case in the ordinary wash box and wet scrubber?

Mr. Egner: I said a moment ago that this question was largely of local application. I think the paper is an extremely valuable one for such works where it can be applied. Very recently I have visited a number of works in the more growing sections of our country, on the Pacific Coast, where they make oil gas as well as water gas. They get a great deal of lamp-black, and burn it as fuel, thus getting steam from the waste and getting rid of the waste at the same time. So you see I think I am right in saying that this question is one very largely of local opinion.

The President: Is there any further discussion? Does any gentleman wish to ask a question? If not, we will hear from Mr. Taussig.

Mr. Taussig: Mr. Searle made a remark on the efficiency of burning CO in the boiler. It is surprising what efficiency you can get from this burning. We have made a number of practical tests, and theory bears it out. We get an evaporation of close to ten pounds of water per pound of fuel burned, from and at 212 degrees, from the CO as fuel burned in that way. As I said in the paper, it does not pay, where generator fuel is high, as a rule, but an evaporation of ten pounds is better than the ordinary gas works evaporation. And when we come to think of it—I assume in this paper an evaporation of eight pounds of water from and at 212 degrees—I doubt very much whether many of our gas works are getting an evaporation continuously day in and day out of eight pounds. An evaporation of eight pounds is a good evaporation in a small boiler plant, where usually the boiler has to do a great deal of extra work. Mention was made that it might not pay in a small plant. It will pay in any plant, more so in a small plant than in a large one because you can run a smaller boiler

and run it to a constant load, say in a small mixed gas plant, and at the same time, when you want the steam for the water gas set, it is being made there automatically. It is surprising how little heat is lost in radiation in the boiler. We have shut our boiler down overnight for fourteen hours; we had steam in at a steam pressure of 95 pounds when we shut down, and the pressure only went down to 74 pounds in 14 hours' time. Of course there is a little gas admitted from the fuel, but we actually lose very little pressure, and if it were necessary, if steam were not used for other purposes, in the summer time particularly, we could make all our steam with this boiler. In one of our plants where we have this boiler running, we have run now for five and a half years. In that time the total repairs have been two tubes replaced, which will answer Mr. Humphreys' question as to the ability of the boiler to stand up. The works boiler is completely banked and practically shut off during the time in which the set is running. We could blow off all the time if we wanted to, and it makes a very great saving in fuel. I figured very conservatively in this summary just to bring it before the people as to how it will pay. Such a cost for boiler plant is tremendous, eight dollars' per thousand feet capacity, or practically almost three times as much as the ordinary boiler plant would be, but it is surprising how the cost of such a thing increases when you put in feed lines, connections, and things of that sort; it makes an expensive plant of it. As to the tar, when you see a single boiler running both blast and illuminating gas, you would be impressed with the fact that practically all the tar must be going out into the air. You see the illuminating gas goes through the boiler, one part of the cycle, depositing a little tar; the blast gas comes along and picks up some of the tar, the lighter tars, you might say, and takes it out into the air, and it makes a yellowish, dry, smoke, which falls to the ground and reminds you of automobiles when you smell it. We made tests of this tar and the loss is not appreciable. The total quantity of tar lost in that would not make more than one-tenth of a gallon per thousand

feet of gas, a very small quantity. It is very difficult to measure accurately, but I can say positively it would not be more than that. Now, I think Mr. Forstall, having the figures in his mind better than I, can probably tell exactly just what this result of friction would be in the pipes on the different specific gravity. I may be in error in that figure, but I doubt whether the difference would be as much as Mr. Forstall has said, because we have had practical experience in the works where our take-off pipes have been too small without the boilers; in fact, we could not run without the boiler; the blast pipes would rise, the stack valves would rise, and as soon as we put the boilers on, the reduction of pressure would be tremendous. We could run very accurately and surprisingly well even with the addition of a boiler at the outlet of the set, due to the reduction in volume, and the shrinkage in the gas reduces the pressure in the set by approximately ten inches of water. You would think it would increase, having a resistance on the outlet, but it reduces the volume, and pressure about ten inches of water through the apparatus on an average. Mr. Egner has been telling about his breeze. There are some plants that really have to get rid of the breeze. They do not want to sell it, at least they do not try to sell it, and they have it in the plant. But I think in a great many instances, if they looked around, they could find a market for their breeze. Or they could sell their steam, if they have it to make. Mr. Norris's correction is right on page 8, and I shall have to make that correspond. Mr. Morris took exception to my remark about the necessity of making CO in some instances. I have known of a great many instances where it would not be practical to change works' conditions for varying candle-powers. In a mixed gas plant at one time they will require five gallons of oil to be used per thousand, and in the next few hours they will have to run three gallons or two gallons; it depends on what their requirements are. Now, in such cases it will be difficult to make enough CO to be burned during the period of the five gallon gas, and then change to a three gallon gas

basis. In such cases it is usually economical to try to average the conditions so as to carry the set over the peaks. If that is done, we can burn, during the time that the oil is low, the excess CO to advantage. As to tar fog which Mr. Wyant speaks of, we think that the proper way to condense gas, as he suggests, is to condense it as gradually as possible. Now, if we put gas at 1,300 degrees into our wash box, of course we cool it promptly down to a temperature, say, of 190 degrees. Then it has to be cooled through the rest of the system. It figures about 150 degrees at the outlet of the wash box. You will not lose much of the illuminants at 150 degrees. The vapor tensions at that point are very high, and I think most of the tar will be carried along.

The President: Gentlemen, Mr. Taussig's paper has been very interesting, not only as a subject for present but for future thought by the members. I think he is entitled to a hearty vote of thanks.

A motion was made, seconded and carried that Mr. Taussig be given a vote of thanks for his paper.

The President: Carrying over one or two matters from the morning session has rather disarranged our schedule, so I will call now on Mr. Mueller to read his paper on

The Extraction of Cyanogen From Coal Gas at the Astoria Works.

Mr. M. E. Mueller then read his paper as follows:

THE EXTRACTION OF CYANOGEN FROM COAL GAS AT THE ASTORIA WORKS.

Before describing in detail the method used for the extraction of cyanogen at the Astoria works, the writer will mention the theory of the formation of cyanogen in the process of carbonization, the reasons for removing it from the gas and the principles involved in the different methods of extraction.

Gas coals contain from one to two per cent. of nitrogen.

In the process of carbonization, roughly one-half of this nitrogen remains with the coke, about one-third appears as free nitrogen in the gas, and approximately one-sixth is converted into ammonia. Besides these three principal outlets for the nitrogen, small amounts are found in the tar and in the form of hydrocyanic or prussic acid (HCN) which passes off with the gas.

Foster (J. G. L. XL—1124) found with coal containing 1.73 per cent. of nitrogen that this became distributed as follows:

In coke	49.90%
In gas	34.04%
As ammonia	14.50%
As cyanogen	1.56%

M'Leod (J. G. L. XCVII—748) reports the per cent. of total nitrogen retained by the coke as varying from 30.2 to 89.6 per cent. with an average of 58.3 per cent. on eighty coals tested; nitrogen as ammonia 17.1 per cent., in tar 3.9 per cent., in cyanogen 1.7 per cent. and in the gas as 19.5 per cent.

Knublauch (J. G. L. LXVI—1242) found that in the gas works at Cologne 1.8 per cent. of the total nitrogen is converted into cyanogen.

The coal used at Astoria averages 1.35 per cent. of nitrogen, which is equivalent to 30 lbs. per ton. Of this slightly over 5 lbs. (equivalent to 24 lbs. sulphate) is converted into ammonia. The amount of cyanogen in the gas averages 110 grains per 100 cu. ft. or 1.73 lbs. per ton of coal carbonized. This is equivalent to 0.93 lbs. nitrogen, or 3.1 per cent. of the total nitrogen of the coal.

The commonly accepted theory regarding the formation of hydrocyanic acid is that it is a decomposition product of ammonia with the hot coke in the retort. This transformation takes place as follows:

$$C + NH_3 = HCN + H_2.$$

Carbon — Ammonia — Hydrocyanic acid — Hydrogen

By passing ammonia over heated charcoal in a porcelain tube, Bueb (J. G. L. LXVII—. 1033) found that hydrocyanic acid was formed and that at temperatures ranging from 1,472° F. to 2,156° F. the amount of cyanogen produced increased with the temperature. At the same time the decomposition of the ammonia into nitrogen and hydrogen increased with the temperature.

Bergmann in continuing the above investigation found that diluting the ammonia with coal gas and passing the mixture over heated charcoal increases the cyanogen formed and decreases the amount of ammonia broken up into nitrogen and hydrogen, and that the most favorable temperature for the formation of cyanogen is in the neighborhood of 1,100° C. (2,012° F.). He also found that only negligible amounts of cyanogen are produced from the interaction of ammonia and carbonic oxide.

$$NH_3 + CO = HCN + H_2O.$$

The fact that cyanogen is a high temperature decomposition product of ammonia indicates that a high yield of cyanogen would be accompanied by a low yield of ammonia. This, however, is not necessarily true, nor do the results obtained at Astoria bear out this conclusion. The facts of the case probably are that a great deal of the ammonia formed during carbonization is decomposed before the gas leaves the retort, most of it into free hydrogen and nitrogen. If such conditions could be approached in the retort that only a small part of the ammonia formed would be decomposed and all of this converted into cyanogen, high yields of both of these products would result. As a matter of fact, in the plants at Astoria, simultaneous high or low yields of both of these products have more frequently been the case than a high yield of one at the expense of the other.

There are two reasons for removing cyanogen from gas. In the first place it is an objectionable impurity, and secondly if recovered in a suitable form it becomes a valuable bye-product. Cyanogen if allowed to remain in the gas becomes objectionable first in the purifiers. Here it combines with the oxide of iron to form ferrocyanide compounds, and the iron so combined becomes unavailable for the extraction of hydrogen sulphide. The purification records at Astoria show a great improvement in the amount of gas purified per bushel per change after the extraction of cyanogen was begun; but on account of the varying conditions in the purifying houses some of this improvement may be due to other causes. The absorption of cyanogen by the oxide although it has a detrimental effect on hydrogen sulphide purification, is beneficial in another direction. Spent oxide containing much ferrocyanide becomes valuable as a raw material for the manufacture of cyanogen compounds and has a better sale than other spent oxide.

The purifiers, however, generally allow a considerable portion of the cyanogen to pass forward with the gas. When this happens the cyanogen exerts a corrosive action on iron and steel with which the gas comes into contact. The blue color often noticeable on the outside of gas holder sheets, especially around leaky rivets is due to cyanogen corrosion. This same corrosion takes place in service and house pipes frequently resulting in a stoppage of the pipe.

The profit to be derived from the extraction of cyanogen depends on the market for ferrocyanides, as it is to these compounds into which the cyanogen is converted. The Census Report of 1905 (Bulletin 92—Bureau of the Census, p. 45), gives the production of potassium ferrocyanide at 5,027,-264 lbs.; valued at $683,277.00, or about 13½ cents per pound. The importation from Europe of sodium and potassium, ferro-cyanide combined for the two years 1908 and 1909, averages about 3,100,000 lbs.; bringing the total consumption in this country to about 8,000,000 lbs. Another authority

estimates the consumption at 6,000,000 lbs. annually, with the production in this country somewhat over half this amount.

Assuming a demand of 8,000,000 lbs. of potassium ferrocyanide, equivalent to about 3,000,000 lbs. of cyanogen, this on a yield of 1¼ lbs. per ton of coal, could be supplied from the carbonization of 2,400,000 tons. If the recovery of cyanogen in gas works and coke ovens became general the supply would be far in excess of the demand. Besides there are other sources of ferrocyanides which must be taken into consideration. The old pot process by which ferrocyanides were made by heating refuse animal matter, principally scrap leather in iron pots with potash, is becoming obsolete, but large quantities of ferrocyanides are now being obtained from the residue of the beet-sugar factories in Europe, which process is about to be introduced in this country. One of the principal uses of potassium ferrocyanide formerly was for the manufacture of potassium cyanide, which is used extensively in gold mining, but the manufacture of potassium cyanide from the ferrocyanide has been superceded almost entirely by synthetic processes. The prospect of the extraction of cyanogen becoming a very profitable operation for gas works is not very good unless new uses for ferrocyanides are found. The principal use at present is for the manufacture of Prussian Blue, in dyeing and textile printing.

In order to understand the extraction of cyanogen from coal gas it is necessary to know something of the chemistry of cyanogen compounds. Hydrocyanic or Prussic acid (HCN) which is the form in which the cyanogen probably exists in the gas is a very weak acid, its acidic properties being even less than those of carbon dioxide or hydrogen sulphide. This means that its power for combining with bases is less than that of the other two acids. A current of carbon dioxide passed through a solution of potassium cyanide will liberate hydrocyanic acid and form potassium carbonate. It is because hydrocyanic acid is such a weak acid that very little of it is absorbed in the ammonia washers as ammonium cyanide. Any

ammonium cyanide formed would be decomposed by the CO_2 and H_2S in the gas and hydrocyanic acid again set free.

Hydrocyanic acid in combining with iron, however, form hydroferrocyanic acid which is a stronger acid than either CO_2 or H_2S. If a solution of potassium cyanide is added to a solution of ferrous salt there is first found a precipitate of ferrous cyanide.

$$\underset{\text{Potassium cyanide}}{2KCN} + \underset{\text{Ferrous sulphate}}{FeSO_4} = \underset{\text{Ferrous cyanide}}{\underline{Fe(CN)_2}} + \underset{\text{Potassium sulphate}}{K_2SO_4}.^{1}$$

On adding an excess of potassium cyanide the ferrous cyanide is dissolved with the formation of potassium ferrocyanide.

$$\underset{\text{Ferrous cyanide}}{\underline{Fe(CN)_2}} + \underset{\text{Potassium cyanide}}{4KCN} = \underset{\text{Potassium ferrocyanide}}{K_4Fe(CN)_6}.$$

Potassium ferrocyanide is not a salt of hydrocyanic acid, but of hydroferrocyanic acid, which acid is formed as a white crystalline precipitate when hydrochloric acid is added to a solution of potassium ferrocyanide. Nor does potassium ferrocyanide possess the characteristics of hydrocyanic acid and its salts, the most pronounced of which is their extremely poisonous nature. Hydroferrocyanic acid being a stronger acid than CO_2 or H_2S, its salts are not decomposed by these two gases; and if conditions are such that salts of hydroferrocyanic acid can be formed, the hydrocyanic acid can be extracted from the gas even in the presence of CO_2 or H_2S. This requires the presence of a ferrous salt with excess of alkali.

Another acid of cyanogen which is stronger than either

[1] To distinguish between soluble, insoluble and gaseous bodies in chemical formulae the following system is often used:

A line over the formula indicates a gas, *e. g.*, $\overline{CO_2}$, $\overline{H_2S}$.

A line under the formula indicates an insoluble substance, *e. g.*, $\underline{Fe(CN)_2}$, $\underline{FeS}$.

A formula written without a line indicates a liquid or soluble substance, *e. g.*, KCN, $K_4Fe(CN)_6$.

H_2S or CO_2 is sulphocyanic acid (HCNS). In the presence of an alkali and free sulphur, hydrocyanic acid is converted into sulphocyanic acid, which combining with the alkali forms a sulphocyanic salt. It is on this principle that the process of the British Cyanides Co. for the extraction of cyanogen from gas depends.

$$(NH_4)_2S + \underline{2S} + \overline{2HCN} = 2NH_4CNS + H_2S.$$

In the ordinary process of gas purification a considerable portion of the hydrocyanic acid is absorbed in the purifiers. In the spent oxide cyanogen is found both as ferrocyanide and sulphocyanide. The amount of the latter compound which is of little value, increases with the amount of ammonia in the gas, so that in order to obtain spent oxide as rich as possible in the more valuable ferrocyanides the ammonia should be removed completely (J. G. L. LXVI—1294). To extract the ferrocyanide from the spent material, the oxide is lixiviated with water to remove the soluble salts. The oxide is then treated with lime to convert the ferrocyanide present into calcium ferrocyanide, which is soluble and is separated from the oxide by filtration. From the solution the ferrocyanide is precipitated by ammonium salts in the form of an insoluble double ferrocyanide of calcium and ammonium, which is converted into potassium ferrocyanide by treating with potassium carbonate.

The methods for the extraction of hydrocyanic acid from the gas in the wet may be divided into two general classes according whether the cyanogen is converted into a ferrocyanide or sulphocyanide. The latter process is that of the British Cyanides Co. and has made considerable headway in England. It consists in washing the gas with ammoniacal liquor to which sulphur has been added. The ammonium sulphide present in the liquor dissolves the sulphur to form a polysulphide $(NH_4)_2S_2$ which reacting with the hydrocyanic acid of the gas forms ammonium sulphocyanide (NH_4CNS).

$$(NH_4)_2S_2 + 2H\overline{C}\overline{N} = 2NH_4CNS + \overline{H_2S}.$$

The ammonium sulphocyanide is converted into either potassium cyanide or potassium ferrocyanide.

A great many different methods have been patented for the extraction of hydrocyanic acid from the gas in the form of ferrocyanide. All of them have this in common; namely, that the gas is scrubbed with an alkaline solution containing an oxide, hydrate or salt of iron. These methods may be grouped under two classes according to whether a fixed alkali such as potash, sodium carbonate or lime is used or whether the gas itself supplies the alkali in the form of ammonia. Of the former class only brief mention will be made. In this according to the method of Foulis the gas after being freed from ammonia is scrubbed with a solution of potassium of sodium carbonate containing oxide or carbonate of iron in suspension. The chemical reaction taking place is as follows:

$$2K_2CO_3 + \underline{FeCO_3} + 6H\overline{C}\overline{N} = K_4Fe(CN)_6 + 3\overline{C}\overline{O_2} + 3H_2O.$$

Potassium carbonate	Ferrous carbonate	Hydrocyanic acid	Potassium ferrocyanide	Carbon dioxide	Water

The cyanogen is directly obtained as a solution of potassium ferrocyanide from which the salt is obtained by evaporation.

One of the first processes using the ammonia of the gas as an alkali for the extraction of hydrocyanic acid is that of Rowland. According to his method an iron salt is added to the water used in the ammonia scrubbers. The cyanogen is absorbed as ammonium ferrocyanide which remains in solution. Before distilling the ammoniacal liquor thus obtained more iron salt is added which upon distillation of the liquor combines to form an insoluble double ferrocyanide of iron and ammonia similar to the product obtained in the Bueb process.

The Bueb process, which is the one in use at Astoria, differs from Rowland's in that only a portion of the ammonia in the gas is absorbed with the cyanogen, the remainder being absorbed in the usual manner, and in that most of the cy-

anogen is obtained directly in an insoluble form. Briefly the process consists in scrubbing the gas before the removal of the ammonia with a solution of ferrous sulphate (copperas). The reactions which take place are as follows:

First the ammonia and hydrogen sulphide of the gas convert the copperas into ferrous sulphide (FeS).

$$\underset{\text{Ferrous sulphate}}{FeSO_4} + \underset{\text{Ammonia}}{\overline{2NH_3}} + \underset{\text{Hydrogen sulphide}}{\overline{H_2S}} = \underset{\text{Ferrous sulphide}}{\underline{FeS}} + \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}.$$

The ammonium sulphate formed remains in solution while the ferrous sulphide is in suspension. After the above reaction has taken place the hydrocyanic acid is absorbed together with more ammonia by the ferrous sulphide with the formation of an insoluble double ferrocyanide of ammonia and iron $[(NH_4)_2FeFe(CN)_6]$, hydrogen sulphide being liberated.

$$\underline{2FeS} + \overline{2NH_3} + \overline{6HCN} = \underline{(NH_4)_2FeFe(CN)_6} + \overline{2H_2S}.$$

Most of the cyanogen is converted into this insoluble double ferrocyanide which is light yellow in color. This double ferrocyanide is, however, partly decomposed by the ammonia and H_2S in the gas into ammonium ferrocyanide, which is soluble, and ferrous sulphide. The black color of the ferrous sulphide hides the yellow of the double ferrocyanide so that the mud in the washer instead of becoming yellow is almost black. This decomposing of the double ferocyanide may be expressed by the following equation:

$$\underline{(NH_4)_2FeFe(CN)_6} + \overline{2NH_3} + \overline{H_2S} = \underset{\text{Ammonium ferrocyanide}}{(NH_4)_4Fe(CN)_6} + \underset{\text{Ferrous sulphide}}{\underline{FeS}}.$$

The ferrous sulphide thus formed can extract more hydrocyanic acid. The longer the material is left in the washer, the more soluble ammonium ferrocyanide is formed, but as it is the insoluble compound which is the final product desired the material is left in the washer only long enough until it has

absorbed sufficient cyanogen to combine with all the iron present in the form of the insoluble compound.

The mud as it is drawn from the washer consists, therefore, of insoluble ammonium-ferro ferrocyanide, insoluble ferrous sulphide; while in solution are ammonium sulphate, from the decomposition of the copperas and ammonium ferrocyanide together with those compounds occurring in crude ammoniacal liquor. To convert the soluble ferrocyanide into insoluble form the mud is either boiled or made slightly acid with sulphuric acid.

On boiling, the ammonium ferrocyanide reacts with the ferrous sulphide as follows:

$$(NH_4)_4Fe(CN)_6 + FeS = (NH_4)_2FeFe(CN)_6 + 2NH_3 + H_2S.$$

While the action of the sulphuric acid accomplishes the same result except that more ammonium sulphate is formed.

$$(NH_4)_4Fe(CN)_6 + FeS + H_2SO_4 = (NH_4)_2FeFe(CN)_6 + (NH_4)_2SO_4 + H_2S.$$

In both cases the insoluble double ferrocyanide is formed and the mud changes color from almost black to light yellow. The final products are therefore an insoluble double ferrocyanide, and a solution of ammonium sulphate, which are separated from each other by filtration.

Only two raw materials are used for the process, viz: Ferrous sulphate (copperas) and sulphuric acid. On a yield of 1.75 lbs. of cyanogen per ton of coal there would be required theoretically 6.3 lbs. of copperas. The actual amount used for three months was 5.66 lbs., which is 90 per cent. of the theoretical. As the efficiency of the washers is about 85 per cent., the amount of copperas used is practically what would be theoretically expected. The quantity of sulphuric acid (oil of vitriol) used for neutralizing the mud is somewhat less than 1 lb. per ton of coal carbonized. The ammonia absorbed in the process is equivalent to from 4-4.5 lbs. of ammonium sulphate per ton of coal. About two-thirds of this appears

as ammonium sulphate and one-third as insoluble ammonia in the press cake.

The cyanogen scrubbers (Figs. 1 and 2) at Astoria are of

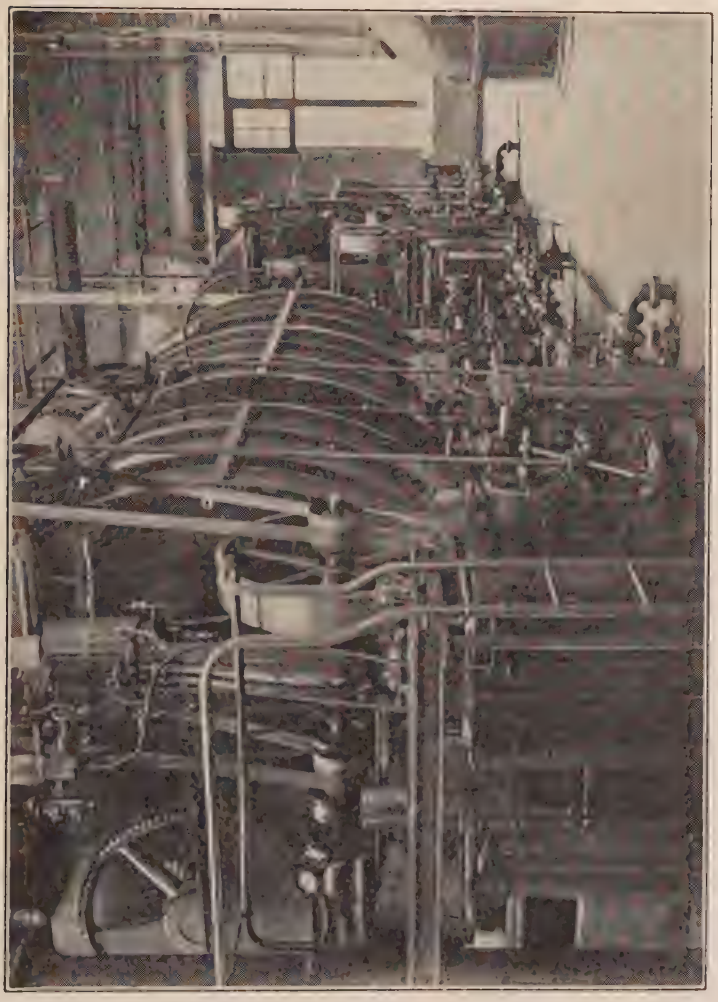


Fig. 1.—Naphthalene and Cyanogen Washers.

the standard type, and are placed after the naphthalene washer but before the condensers. They are 12 ft. in diameter and

divided into five compartments. Four of these are filled with rotating wooden bundles and are used for the extraction of cyanogen, while the fifth at the gas outlet end of the washer contains 12 perforated iron plates spaced about three inches apart. These plates also rotate with the shaft of the washer. The function of this compartment is to convert the ferrous sulphate into ferrous sulphide and ammonium sulphate. Experience has shown that this bay which we call the agitator, is hardly ample for the work. With only 12 plates and these not arranged so that the gas must pass between them, the copperas solution is not exposed to the gas sufficiently to convert it entirely into ferrous sulphide in case it is necessary to empty more than two bays from the washer on the same day, and if the copperas solution is pumped forward into the bays filled with wooden bundles before this conversion is complete it is almost sure to cause a stoppage.

At the side of the washer are two pumps driven from the engine which turns the bundles. The suction and discharge pipes of these pumps are arranged so that all the necessary operations of pumping the copperas solution into the washer, advancing it from one compartment to another, and discharging the mud after it has become saturated, can be done with them.

When the cyanogen washers were first put in use it was found that the cyanogen absorption was far from being complete. In order to provide greater capacity the connections on the last four bays of the naphthalene washers, which are placed immediately before the cyanogen washers, were changed so that they could be used for the extraction of the cyanogen. This practically doubled the absorbing surface available for cyanogen extraction and improved the efficiency. But even now with the increased area for absorption the washers will at times absorb as low as 50 per cent. of the cyanogen. Then, again, for no apparent reason, the efficiency will increase to 95 per cent. On the average about 85 per cent. of the cyanogen is extracted. The extraction appears to be more complete in the cold weather than in summer, notwithstanding

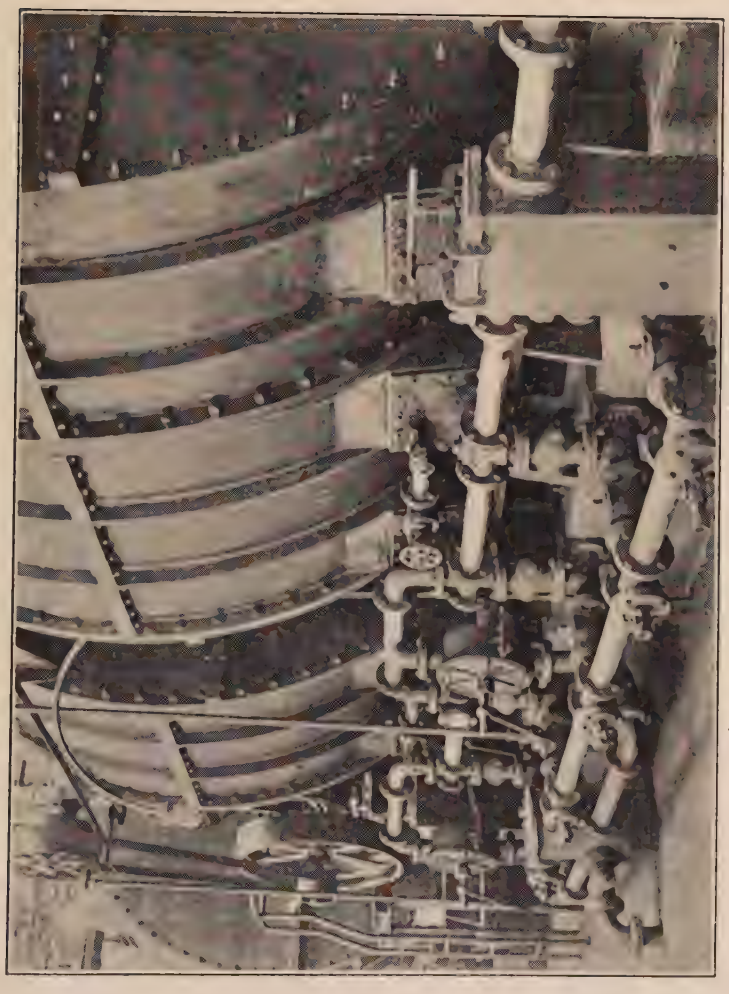


Fig. 2.—Cyanogen Washer, showing connections.

the fact that more gas is passing the washers. This is probably due to some extent to the greater condensation of water taking place during the warm weather and consequent dilution of the absorbing material.

In explaining the operation of the Bueb system as carried

out as Astoria, it will be assumed that the washers are empty and about to be put into use. The copperas solution is made in concrete waterproofed tanks provided with motor driven paddles. Fresh water or wash water from the filter presses is put into these tanks and the requisite amount of copperas is run in from graduated hoppers. For every 700 gallons of water, which is the amount required to fill the agitator of the washers, 2,400 lbs. of copperas is generally used. During the warm weather a little more copperas is used to allow for the condensation from the gas in order that mud does not become too thin. This solution of copperas is pumped into the agitor bay of the cyanogen washers the other bays being left empty until the ferrous sulphate has been converted to ferrous sulphide in the agitator by the action of the gas. This is ascertained by drawing off a little of the liquor from the agitator, filtering and adding a solution of ammonium sulphide (crude gas liquor) to the filtrate. If the filtrate remains clear the conversion of sulphate to sulphide has been completed. The mud in the agitator is now pumped into the two preceding bays. The proportions of the washer are such that the capacity of the agitator is equal to two of the bays used for cyanogen absorption. The agitator is filled with a fresh solution of copperas. When this has been converted into ferrous sulphide, the mud in the preceding bays is pumped into the two bays ahead and the agitator again emptied into the two preceding bays and filled with fresh copperas solution. This operation is repeated until all the bays of the washer are filled. When the mud in the first two bays has become saturated, it is pumped to the storage tank and the mud in all the other bays moved forward, and the agitator again filled with copperas solution. To test whether the mud in the washer has absorbed sufficient cyanogen a sample is taken and acidified with sulphuric acid. After stirring well a drop of this mud is put on a piece of white filter paper. Near it is put a drop of dilute ferric chloride solution so that the liquid from the two drops as they spread out on the paper will come together. A blue color occurring at the point where

the drops meet is a sign that the mud contains an excess of ferrocyanide over iron and is therefore ready to be drawn off. This test is very simple and is made by the man who attends the other operations of pumping, filling, etc.

In order to simplify the operations some of the washers have been altered so that the flow of the absorbent liquid through the washer is continuous. The copperas solution is run into the agitator in a small stream and the saturated mud overflows from the first bay. When the test of the mud in the first bay shows that it has not absorbed sufficient cyanogen, the copperas solution is stopped and not run in until the material in the first bay is saturated. This makes the operation of the washer much easier as the only pumping required is the filling of the overhead tank with copperas solution.

The mud from the mud storage tank is pumped into covered lead lined neutralizing tanks provided with paddles, which keep the material agitated, where it is neutralized with sulphuric acid and heated to about 200° F. The acid (oil of vitriol) is stored in a steel tank from which it is forced by means of compressed air into small lead lined tanks resting on top of neutralizing tanks. In these tanks the acid is diluted with about three times its volume of water. The addition of acid changes the color of the mud to light yellow. During this operation large quantities of hydrogen sulphide are set free. In order that this does not escape into the room the tanks are fitted with vent pipes connected to a fan which discharged the gases out of the building. Enough acid is used so that the material is slightly acid to litmus. The mud is again tested for soluble ferrocyanide with ferric chloride solution on a piece of white filter-paper and if the blue color results as it generally does, copperas solution is added a few pailfuls at a time until the blue color no longer appears on testing. The action of the copperas is to precipitate the soluble ferrocyanide.

$$\underset{\text{Ammonium ferrocyanide}}{(NH_4)_4Fe(CN)_6} + \underset{\text{Copperas}}{FeSO_4} = \underset{\text{Ammonium-ferro ferrocyanide}}{(NH_4)_2FeFe(CN)_6} + \underset{\text{Ammonium sulphate}}{(NH_4)_2SO_4}.$$

The mud now consists of insoluble double ferrocyanide of ammonia and iron and a solution of ammonium sulphate with a

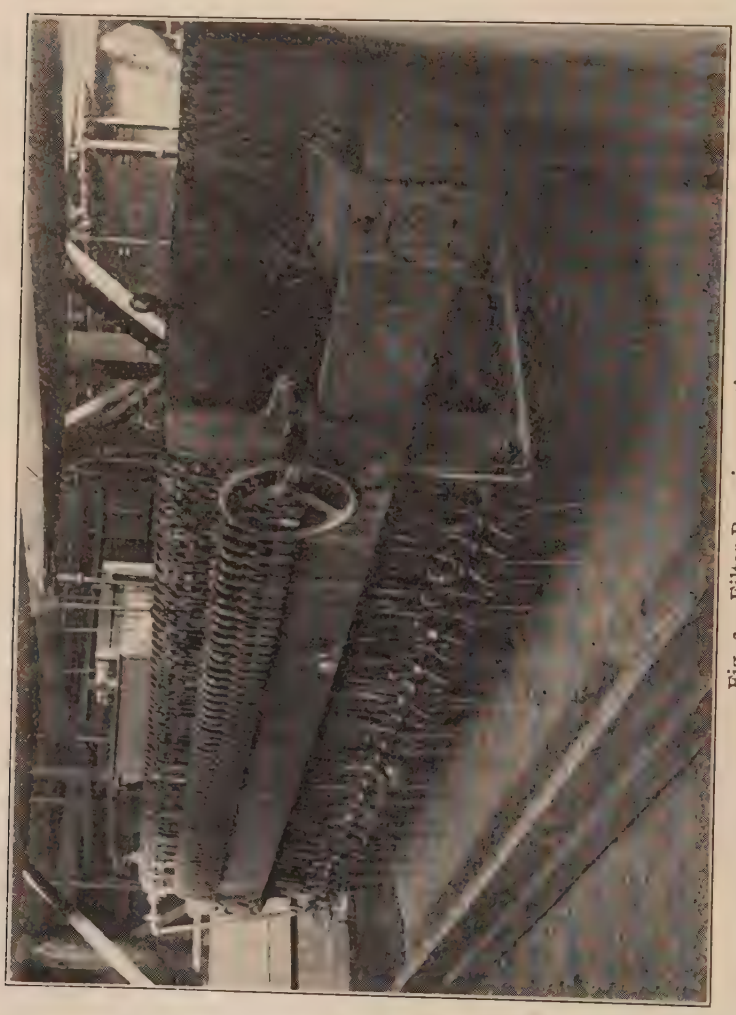


Fig. 3.—Filter Press in operation.

little ferrous sulphate and very little free acid. This mud is pumped into filter presses (Fig. 3). The pumps used for this are lined with acid bronze. After the press is full hot water

is pumped through in order to wash out as much as possible of the ammonium sulphate. The wash water which is a very

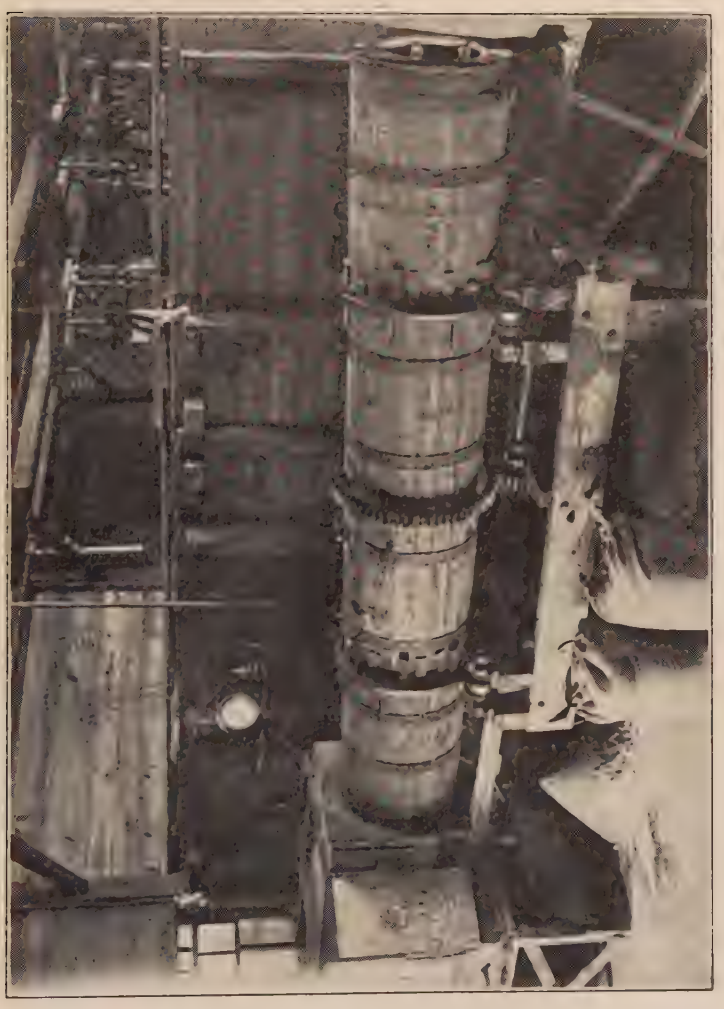


Fig. 4.—Sulphate Dryer.

dilute solution of ammonium sulphate is used for making up the copperas solution. Even with a washing press it is very difficult to wash out the ammonium sulphate. The best results

are obtained by finishing the pressing with mud made by stirring up some of the finished press cake with water until it

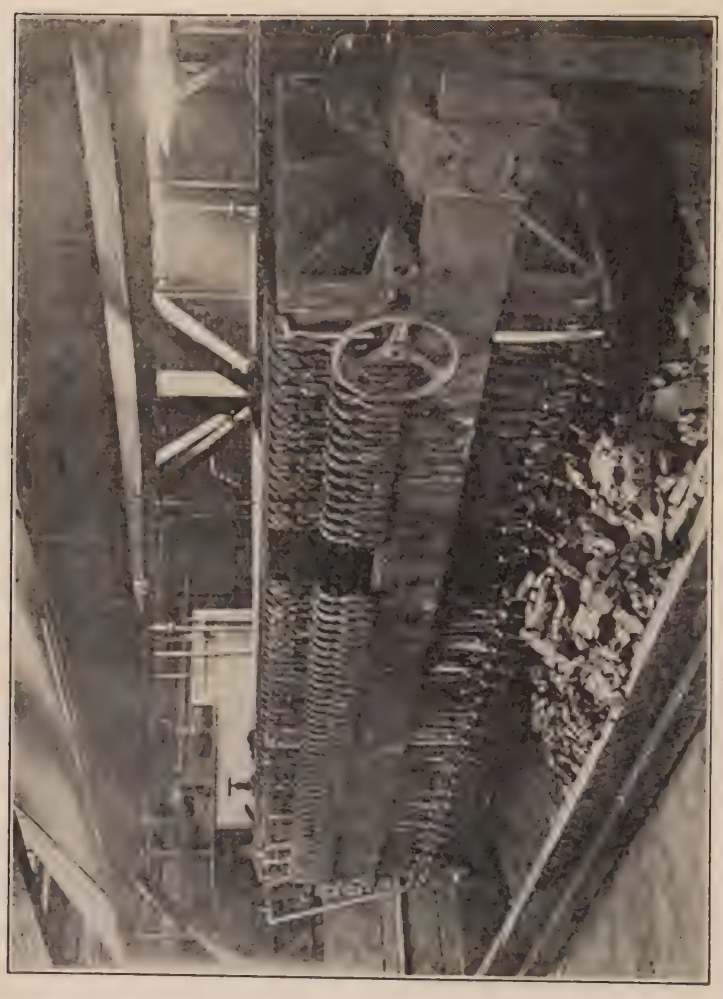


Fig. 5.—Filter Press partially emptied.

disintegrates. The presses are about two-thirds filled with the neutralized mud from the washers and then finished with the mud made from the finished cake. In this way the gravity

of the liquid coming from the presses is brought down from 8-10° Baumé to 1-2° before washing with water.

The solution of ammonium sulphate which runs from the filter presses is neutralized with ammonia. For this purpose some of the mud as it comes from the washers is boiled and the gases, principally ammonia and hydrogen sulphide passes into the ammonium sulphate liquor from the presses. This not only neutralizes the free acid but also precipitates the small amount of iron present. This is necessary to avoid discoloration of the sulphate. The neutralized liquor is allowed to settle and the clear solution evaporated in lead lined pans. This solution contains approximately one pound of ammonium sulphate per gallon. The sulphate separates out on evaporation and is dried in a rotary drier (Fig. 4) by means of a current of air from a small blower heated by passing over steam radiators before passing through the drier. About 2.5 to 3 lbs. of sulphate are produced per ton of coal carbonized.

The cyanogen cake from the filter presses (Fig. 5) is sufficiently firm to be handled with a shovel and bagged. It contains on the average by weight 50 per cent. of water, 20-24 per cent. of cyanogen and 5-6 per cent. of ammonia. About six lbs. of press cake are produced per ton of coal carbonized. When the cake first comes from the presses it is yellow in color but on contact with air it rapidly turns deep blue due to oxidation.

The cake as it comes from the presses is bagged and sold to chemical works where it is converted into potassium or sodium ferrocyanide. This is done by boiling with a solution of caustic potash or soda whereupon the ammonia distills off and ferrocyanide of potash or soda is formed. This is filtered from the residue of iron hydrate evaporated and purified by recrystallization.

Appendix--Estimation of Cyanogen in Coal Gas.

To determine the amount of cyanogen in gas, the cyanogen is converted into potassium ferrocyanide by passing the gas through a caustic potash solution containing freshly precipi-

tated ferrous hydrate in suspension. After filtering the potassium ferrocyanide is determined in the clear solution by acidifying and titrating with a standard solution of zinc sulphate until all ferrocyanide has been precipitated as zinc ferrocyanide.

The end reaction is determined as follows:—A drop of a one per cent. solution of ferric chloride is put on a piece of white filter-paper absolutely free from iron (Schleicher & Schull No. 601). A drop of the liquid being tested is then put on the paper near the drop of ferric chloride so that the liquor as it spreads out on the paper will come in contact with the ferric chloride. Care must be taken that that the precipitate of zinc ferrocyanide does not come in contact with the iron solution. As long as there is any ferrocyanide left in solution, a blue color will appear where the two drops come in contact due to the formation of prussian blue. When all ferrocyanide has been precipitated this color will no longer appear, which indicates the end point of the titration.

The zinc sulphate solution is made by dissolving approximately 5 grams of c-p. zinc sulphate ($ZnSO_4.7H_2O$) in one liter of water with the addition of 10 cc. of sulphuric acid. This solution is standardized with a solution of potassium ferrocyanide (10 grams c-p.—$K_4Fe(CN)_6 3H_2O$ per liter). 25 cc. of the potassium ferrocyanide solution are put into a beaker and titrated with the zinc sulphate solution, the end reaction being determined as above. One cc. of the ferrocyanide solution is equivalent to 0.0570 grains of cyanogen, from which the value of the zinc solution is calculated.

To test for cyanogen in gas put 15 cc. of a 10 per cent. ferrous sulphate ($FeSO_4.7H_2O$) solution into each of three wash-bottles. Add 15 cc. of 20 per cent. caustic potash solution to each bottle and pass about three cu. ft. of gas through these bottles at the rate of about one cu. ft. per hour. Rinse the contents of the bottles into a beaker, add 20 cc. more of the caustic potash solution and heat to boiling. Filter and wash with hot water until a few drops of the filtrate no longer

shows a blue color when acidified and tested with a drop of 1 per cent. ferric chloride solution. Transfer the filtrate to a 500 cc. graduated flask, dilute to the mark and shake well. Take 100 cc. of this solution and transfer to a beaker by means of a pipette. Slowly add dilute sulphuric acid (1.5) stirring constantly until the solution shows slightly acid towards litmus. Then run in the zinc sulphate solution a few drops at a time until the drop test as explained above shows that the ferrocyanide has all been precipitated. From the amount of zinc sulphate solution used the amount of cyanogen in the gas is calculated.

The method used to determine the percentage of cyanogen in the press cake is similar. A sample of the cake (about 10 grams) is boiled with caustic potash solution during which operation the ammonia distils off and may be estimated by absorbing in standard acid. In this way the ferrocyanides are converted to potassium ferrocyanide. The solution is made up to one liter in a graduated flask, allowing 5 cc. for the solid matter, filtered and the cyanogen determined in an aliquot part of the filtrate.

THE PRESIDENT: Gentlemen, you have heard this very interesting paper. Much credit for the successful operation of this plant is due to Mr. Mueller. Is there any discussion?

MR. W. H. FULWEILER: This paper of Mr. Mueller's is certainly exceedingly interesting. I think it is one of the first papers we have ever had treating of the practical operation of a cyanogen recovery plant in an American gas works. Aside from the technical interest of the paper, its value lies in throwing some light on the commercial possibility of the process under American conditions.

As cyanogen does not generally exist in the illuminating gas as received by the consumer, to such an extent that its presence amounts to a serious impurity, its removal has not awakened the interest in this country that it has abroad. It is necessary for the process to show some decided saving per

thousand cubic feet for it to appeal generally to the American profession.

While I judge from Mr. Mueller's paper that he does not advocate the universal adoption of cyanogen recovery, it would be interesting if he could give a somewhat more detailed idea of the probable net returns from its operation, say, in addition to his present figures, the labor required in the operation of the plant, including supervision. This, it appears, must be somewhat of an item in the handling of the process.

There are apparently some four reactions taking place whose correct and economical control would seem to require some technical supervision,—

The formation of the ferrous sulphide.
The saturation of the mud in the washer.
The neutralization of the mud.
The neutralization of the wash liquor.

It would seem that improper or careless handling of any one of these would result in considerable loss of efficiency.

In Germany, where this process was developed technically trained men can be secured very much cheaper than in this country, and it would be of interest to know how much trained supervision is required.

The fact that the practical results at Astoria have shown that simultaneous high or low yields of both ammonia and cyanogen were more usual than the expected high cyanogen with low ammonia, or vice versa, is certainly very interesting, and I would ask whether this is determined by the actual yields obtained from respective recovery plants or from tests made in the crude gas. If the former method was used, it is, of course, quite conceivable that seasonable variations in the efficiency of the operation of the plant might account for some of this difference. What effect has this on the ammonia yield? Has Mr. Mueller any idea of the minimum size of installation that could be profitably operated, taking into consideration the probably future lowering in the price of cyanides by reason of the synthetic process.

THE PRESIDENT: I will ask Mr. Dewey to make some remarks on this question of cyanogen extraction.

MR. V. F. DEWEY: I asked my chemist to prepare some figures. I am simply reading the figures that he prepared.

Regarding the figures given for distribution of the total nitrogen in coal among the products of coal gas manufacture —Bunte, Journal of Gas Lighting, June 28th, 1910, examined 17 coals and apportions the Nitrogen as follows:—

60 per cent. in coke
20 per cent. in uncombined nitrogen in gas.
15 per cent. as NH_3 in gas.
3 per cent. as cyanogen in gas.
2 per cent. in tar.

From the general tone of the paper, the high initial cost of the apparatus, and the high cost of maintenance, cyanide extraction would seem to be of doubtful desirability for ordinary plants unless, as Mr. Mueller suggests, the life of the purifying material is largely increased thereby. Generally speaking, one would expect the largest amounts of cyanogen to be produced at the works where the heats are highest, and more particularly where there are limited areas of high heats, such as hot zones in retorts, or one standpipe serving three retorts. The fact that no relation seems to exist between the ammonia and cyanogen yields might indicate that other reactions than those mentioned in the paper take place in the retorts. However, low ammonia yields in conjunction with high cyanogen yields have been observed in various places.

Station B, in Detroit produces about twice as much cyanogen as Station A, on account, probably, of hot zones in the retorts, and particularly because, in these benches of nines, one standpipe serves three retorts. Nevertheless, the ammonia yield has always been distinctly lower at this station than that at Station A of the same company.

I would like to ask if the cyanogen yield estimated as per cent. of ammonia yield varies. In the same works, under the same conditions, this per cent. should be constant. This would

explain Mr. Mueller's phenomena of high ammonia yields coupled with high cyanogen yields, and conversely.

The method given for estimation of ferrocyanide (Mueller's method) does not, according to various authorities, give results even approximately proportional to the amount of ferrocyanide present: *e. g.*, if one sample of press cake contains 10 per cent. ferrocyanide and another 20 per cent., the latter will not take exactly twice as much zinc sulphate solution to arrive at the end point, as the first sample. In fact, the ratios may vary widely. This is thought (cf. Clenell, "Cyanide Reactions" Appendix, p. 157) to be due to the existence of various ferrocyanides of zinc found under different conditions. This is all the more a deceptive method, as two samples of press cake containing the same amounts of ferrocyanide, duplicates on the same sample, will check very closely.

A short, and at the same time, fairly reliable method is that known as Hurters, described in Clenell, "Cyanide Reactions," p. 153.

In this method, the ferrocyanide is decomposed by KOH, filtered, acidulated, converted into ferrocyanide by bleaching powder or bromine water, and titrated directly against $CuSO_4$ solution which has been standardized against material of a similar composition to that under examination.

A somewhat longer, but more accurate method is that of separating the ferrocyanide, decomposing with acids, precipitating the iron with NH_4OH, filtering, and titrating the iron with permanganate.

Methods involving the precipitation of the ferrocyanides as prussian blue are fairly accurate, but the necessary washings are very tedious.

THE PRESIDENT: We will postpone further discussion of this cyanogen paper until directly after luncheon, at 2 o'clock.

MR. MCLEAN: I wish to say a word in connection with the report of the Committee on Public Relations. In the past this Institute has had no committee on Ethics, and occurrences in various parts of the country would seem to indicate that if

such a committee existed, it might have had in some cases a beneficent influence. I would not ask that the Institute at this time commit itself in any way on the matter, but I should like to make a motion that the Committee on Public Relations be requested to report at the next meeting upon the advisability of having a committee on Ethics in the Institute.

THE PRESIDENT: I believe the general scheme outlined for the Public Relations Committee was intended to include such maters. Unfortunately circumstances have arisen which have made the report of the Public Relations Committee this year rather short and not much to the point, but there were good reasons for that. I think the Institute should have a committee on Public Relations to take up subjects that come up between the public and the Gas Companies, discuss them, make records of them, and report to the Institute, then let the Institute take such action on the matter as may seem proper.

MR. MCLEAN: Certainly. I do not wish at this time to take up the time of the Institute in defining the scope of this Committee's work. All I wish to move is that the committee report upon the advisability, or the inadvisability, of having such a committee; whether this committee be subsidiary to the committee on Public Relations, or whether a separate committee be constituted for the purpose of attending to such matters.

THE PRESIDENT: I think the proper course to take would be this: The present Public Relations Committee will probably die this afternoon or tomorrow as a committee, and a new committee will be appointed for next year. That committee should receive instructions from the incoming executive, whoever he may be, as to what they should do.

MR. MCLEAN: That is the idea, Mr. President.

The motion was seconded.

THE PRESIDENT: If there is no objection we will——

DONALD MCDONALD, of Louisville: That motion was made and seconded. Mr. McLean evidently wants action on it, and I cannot see any objection at all, I do not see how this body

can ever make its will known, if it is to wait until the committee for next year is appointed before it undertakes to instruct them

THE PRESIDENT: It has been regularly moved and seconded that the Committee on Public Relations be requested to report at the next annual meeting as to the advisability of having a committee on Ethics.

MR. CHARLES M. COHN: I think the Public Relations Committee should be allowed to use its own judgment as to the matter it covers. I do not understand the American Gas Institute to be a paternal body to pass on the moral actions of the members; therefore I am heartily opposed to the motion as made.

MR. DONALD MCDONALD: I seconded that motion. I presume discussion on it is in order, and I confess that unless I had had some private talk with McLean, I would not have had a very clear idea what it meant, but as he explained it to me, it seems to me that it is a perfectly proper committee to have At any rate, if it is not a proper committee to appoint—I am opposed to too many committees—it is proper to instruct the Public Relations Committee that they should exercise the duties of a Committee on Ethics. In every body or association I believe there are certain rules, which the members are expected to observe in their relation to each other. Among the doctors there are certain things that are professional and certain other things that are not professional, and it is only by having those things passed upon by some authoritative body that anyone will ever know what is expected of him; and it is very much better that a member of this Institute should report to a Committee on Ethics, some action by another member which he considers derogatory to the interests of the gas men of this country, than that he should gossip around the corridors about it and feel sore about it, and get up factional feeling. Whether or not there is a need for this committee, I am not prepared to say, but certainly there can be no harm done by the Committee on Public Relations reporting to the next convention

whether, in their judgment, there should be such a committee appointed, or whether some committee already standing should exercise the functions of such a committee. That is the question as I understand it.

MR. COHN: I think the committee should not be required to report.

MR. DONALD MCDONALD: "Requested," I think, was the words.

MR. COHN: That is practically the same as requiring.

MR. DONALD MCDONALD: I would not so consider it, and if they should report "No," that would end it.

MR. COHN: I think that would be putting the committee in a false position, to require them to say no. I think it can be left to their own judgment as to whether they should report at all on the proposition.

MR. DONALD MCDONALD: I move as a substitute, that the matter be called to the attention of the Committee on Public Relations by the incoming administration.

THE PRESIDENT: I should imagine that was a question more properly for the directors.

MR. WALTON CLARK: I second the substitute, that the matter be called to the attention of the committee on Public Relations. Mr. McDonald moved as a substitute to his own motion, that the matter be called to the attention of the Public Relations Committee, leaving them free to act, and I second the substitute.

THE PRESIDENT: The motion has been changed, gentlemen, that the attention of the Committee on Public Relations be called to the propriety of the appointment of a committee on Ethics, to report at the next annual meeting. Are you ready for the question?

The question was called for and on being put was carried.

THE PRESIDENT: Now, gentlemen, we will adjourn for lunch. Two o'clock is the hour for reassembling.

(The Convention then adjourned for luncheon at 12:40 P. M.)

Wednesday, October Nineteenth.
Afternoon Session.

The afternoon session was called to order by the President at 2:18 P. M.

The President: We will now take up and finish the discussion on the cyanogen paper.

Mr. J. M. Morehead: I cannot say that I am qualified to discuss this question, because we have done nothing in connection with cyanogen at the gas plants in Chicago with which I am associated, but there was a peculiar phase of it that came up four or five years ago in connection with some electric furnace work. The Union Carbide Company made calcium carbide by the reducing action of coke on lime in the electric furnace, and in the process a third of the coke or carbon which is put in the furnace, and all of the oxygen of the lime, went off as carbon monoxide. We caught that and used it in the lime kilns for burning lime, putting it through a long overhead conductor or pipe and during the winter the pipe and the trestle work became covered with icicles. We examined some of those permanent icicles to see what they were, and they turned out to be calcium cyanide. We then started to work to see if we could recover this cyanide from our furnace gases, and after doing a great deal of work on it, we found that it did not pay. Then we went to work to increase the amount of cyanogen by putting air into the electric furnaces, but the temperature was extreme, so that while we did increase the cyanogen a little, the nitrogen would combine with the carbon and make calcium cyanogen, and the oxygen would combine with the electrodes, and altogether it did not pay. After some three months' work, we abandoned it, but it was so far as I know one of the early attempts in this country to recover cyanogen.

Mr. Egner: I want to ask a question. How much in dollars and cents does it bring us if we take it out? That is the first thing I should like to know.

THE PRESIDENT: Are there any other questions on this subject? Is Mr. Mueller in the room?

MR. MUELLER: Mr. Fulweiler asked about the labor in connection with this process of extracting cyanogen. As we are running now at Astoria, making about 12 million feet of gas a day, the labor required is one foreman, four men on the filter presses, one man to attend the washers and do the pumping on the washers, two men to crystallize the sulphate, dry and bag it, one general man who attends to minor repairs, and one night man. That is a total of ten men. That same force will be sufficient for a make of about 15 million feet a day. This labor it the only labor required in the actual operation. It does not include the repairs, which are quite heavy both on the washers, as well as on the other apparatus used in the finishing up of the work. Mr. Fulweiler also remarked that the reactions appeared to be quite complicated and would require a considerable amount of supervision, but after the men get accustomed to the work they are very simple, and it is only when things go wrong, when they open the wrong valve or pump things into the wrong tank, that causes considerable trouble in straightening things out again. In relation to the ammonia and cyanogen, it was not my intention to give the idea that a high cyanogen yield always accompanies a high ammonia yield, but on the other hand I merely wanted to refute the general impression that a high cyanogen yield was at the expense of the ammonia. When I speak of cyanogen yield, I mean the actual cyanogen contained in the gas, and not the yield of the precipitate which we obtain, which of course differs with the efficiency with which the washers are being operated. Mr. Fulweiler also asked about the return from the ammonia in the press cake. I may say that the ammonia in this form is about the same as in the crude liquor. Now, as to the minimum installation that would pay, I am hardly prepared to say, because the incidental advantages which accrue from extracting cyanogen are a little hard to take into consideration, but I do not think it would pay to extract

cyanogen in a plant making less than two millions a day. Of course that figure is only an estimate on my part; I may be wrong. Mr. Dewey took exception to the method we used for analyzing and testing cyanogen and analyzing the press cake. All I can say in defense of the method that we use is that it is the method which has been adopted between us and the purchasers of the material, and it has been found satisfactory. I myself have great faith in the method if it is carefully worked out.

THE PRESIDENT: Gentlemen, the extraction of cyanogen, as has been remarked here, is a comparatively new subject, but there is food for thought in it, and Mr. Mueller has given us a very elaborate paper on the subject. I think a vote of thanks is due to Mr. Mueller, if somebody will move it.

MR. NETTLETON: I move that a vote of thanks be given to Mr. Mueller for his paper.

The motion was seconded and carried.

THE PRESIDENT: There is one matter deferred from this morning, the report of the committee on

CAST IRON PIPE STANDARDS.

If the committee is ready to report, we will hear that now.

The report of the committee was read by Mr. William Cullen Morris, as follows:

Mr. President:—Your Committee begs to report progress. It had been the intention of your Committee to make a final report advising that they had been unable to arrive at an agreement with the founders, and that under the circumstances they would present for adoption the standards as prepared by the Committee. There has, however, been received a request from one of the large foundry interests that this action be deferred another year, intimating that an agreement may be arrived at between the foundry interests and your Committee as to standards acceptable to both. In view of this, although

your Committee regrets the necessity, it appears advisable to recommend that the Committee be continued and instructed to report for final vote of the Institute at next year's convention.

C. C. SIMPSON, Chairman.

THE PRESIDENT: Gentlemen, you have heard the report of the committee on cast iron pipe standards. What is your pleasure?

A motion was made, seconded and carried that action be taken in accordance with the recommendations of the committee.

THE PRESIDENT: We will now listen to a paper by Mr. J. M. Morehead on

DETERMINATION OF THE CALORIFIC VALUE AND OF OPERATING CONDITIONS FROM ANALYSIS OF INDUSTRIAL GASES.

Mr. Morehead then read his paper as follows:

DETERMINATION OF THE CALORIFIC VALUE AND OF OPERATING CONDITIONS FROM ANALYSIS OF INDUSTRIAL GASES.

Scientifically, the word GAS is used to distinguish any substance existing in a permanently elastic condition as distinguished from other substances existing in either of the other two ordinary natural states of matter, viz: liquid and solid. A permanent or fixed gas is one which cannot be reduced to the liquid or solid state by pressure alone. A gas which can be liquefied by pressure, at ordinary temperatures, is usually called a vapor.

Ordinarily, the word GAS is used to designate any substance, or combination or mixture of substances, not a solid or a liquid which cannot be touched or seen, and all substances or mixtures having these two characteristics are included under the one general term GAS. As a matter of fact gases present far more diverse physical and chemical

characteristics and differ much more widely among themselves than do either solids or liquids. For examples of these striking differences see Appendix B.

Industrially, the word GAS is restricted to substances which are used for burning for either light, heat or power, and while we speak of illuminating gas, or of fuel gas, we must remember that any industrial gas is a complex mixture of a number of diverse constituents.

There may be a vast difference between one gas and another gas and there is a possibility of even vaster differences between mixtures of gases when the mixtures are made up of a number of constituents, and the nature of any such mixture can be profoundly effected by changes in the relative percentages of its component parts.

The importance of an analysis of the many forms of gas either produced or consumed in ordinary industrial processes is not thoroughly appreciated. If the great economic value of the light shed upon the condition of the machines, the fires, the retorts, the furnaces, the engines, or other gas making or gas using apparatus by a gas analysis were better understood, and if the simplicity and economy of the apparatus, and the ease of the process of analysis were more apparent, this form of research and this aid to station operations would be more nearly universal.

The photometer will tell a Superintendent the fact, if his product is not up to standard in light-giving power, the calorimeter will tell him that the heating power is not up to standard, but the discussion of the chemical analysis and the study of the data thus obtained, and only these, can tell him the reasons for the facts of which the other two processes of investigation assure him.

Neither one of these methods of investigation and checking can take the place of the other two, the photometer will quickly make it plain if the luminosity falls off, but this is a consequence, not a reason; so also the calorimeter will say

this gas is deficient in heat value, but only the chemical analysis and its intelligent study can give the reasons why, of either or both of these unfortunate facts.

A deficit of air in boiler firing will result in the incomplete burning of fuel to carbon monoxide and the production of 4,500 heat units to the pound instead of to carbon dioxide and the production of 14,500. An excess of air will overflow a fire, dilute and chill the flue gases and cause the needless heating of large quantities of air which escape up the stack. Too much or too little air will often cause boilers to work at a lower efficiency than can be offset by superior fuel, patented grates, damper regulators or high priced settings.

An analysis of chimney or flue gas will tell definitely and accurately the conditions as to the air supply of a boiler.

An analysis of the exhaust from a gas engine will tell whether there is too little air and incomplete combustion which lowers the efficiency of the engine and affects the power bill, or whether there is an excess of air which takes the place of the mixture of gas in the cylinder, and thus lowers the available horse-power.

In gas works, in iron and steel plants, with gas producers, in all forms of furnaces and for ventilating purposes, an analysis of the gas will give information upon the condition of the apparatus, will detect leaks of air, or gas, and will serve as an index to the character of the changes taking place inside of the apparatus. All of which knowledge can be turned by the manager to most advantageous economical account.

From answers received to two hundred and twenty inquiries in regard to gas analysis sent to those gas companies in the United States and in Canada having a daily send-out of 250 M or over, and to the principal gas engine and gas producer manufacturers, it is clear that gas analysis receives very little attention, especially in the smaller compa-

nies, and even among the larger ones the methods, apparatus and constants vary very widely.

One hundred and four answers were received. Only one company declined to give any information. About one-third reported that they had no information along the lines asked for, the balance returning more or less complete answers.

From the answers received, thirty-one analyze some sort of gas regularly, twenty-one occasionally and fifty-two not at all.

The distribution of analysis, either regular or occasional, was as follows: there being, of course, a number who analyze more than one kind of gas.

Flue gas	36
Water gas	34
Coal gas	33
Mixed gas	24
Producer gas	10
Natural gas	6
Engine exhaust	6
Pintsch gas	5
Oil gas	4
Air	2
Furnace gas	2
Acetylene	1

Thirty-eight of the fifty-seven companies analyzing their gas use the results obtained as an aid in their station operations, just why the other nineteen make the analyses does not appear.

Fifty-seven companies determine the calorific value of their product, of these forty-six use Junker's calorimeter, ten use Sargent and one uses the Doherty, forty-seven companies do not use any calorimeter.

Thirty-eight companies calculate the calorific value from their analysis, seventy-four do not.

The constants for the calculations were:

	Highest	Lowest	Average
Illuminants	2,257	1,621	1,888
Carbon monoxide.	350	317	333
Hydrogen	350	319	334
Methane	1,600	915	1,054

The average agreement between the calculated and the determined B. t. u. by those who arrived at the calorific value both ways was 3.75 per cent.

This emphasizes the importance of some authoritative action on the part of such an Association as this looking towards some sort of standardization.

The chemical and physical examination of gas is in and constitutes a branch of chemistry and of physics peculiar to itself. The very nature of the gas business makes the requirements peculiar.

In other branches of analytical chemistry there is always some stock of material on hand from which a second sample can be drawn, or a check analysis of the sample already taken can be made, but under ordinary conditions there is never any considerable stock of gas on hand, and to have any value at all a gas analysis must be finished and reported within a very few hours of the time when the sample is taken, otherwise the gas of which the sample was a part is gone, and while the results may have some interest as a record of what the plant *has* done, it can be of no value as an indication of what the plant *is* doing and to have such value a method which can be carried out in a short time must be available, and dispatch in the performance of the analysis is an essential.

There is practically only one method of gas analysis. This was worked out many years ago by Bunsen, Hempel and

Winkler, and consists in the successive absorption with different chemicals of the various constituents of the gas. Various modifications of this method are used with the different types of apparatus now employed.

The principal designs of gas analyzing apparatus may be grouped into two classes. First, those which keep the reagents in what may be called a stationary position and pass the gas through the reagents, using the same chemicals over and over, and second, those which keep the gas in a stationary position and pass the chemicals through the gas using the chemicals in this case only once. The apparatus of the first class has the advantage of greater economy in chemicals and is not so sloppy in use, but in the opinion of the writer these advantages are more than offset by the fact that the analyst never knows just when the solutions are exhausted below a point where they will give accurate results.

There can be no such uncertainty with apparatus of the second class, as fresh solutions are always being used and there is no possibility of the chemicals having been weakened or exhausted by previous analyses.

All modern designs of gas analyzing apparatus come under these two heads and are modifications of what might be called these two standard types.

In the first class is Hempel's apparatus (Fig. 1) which is perhaps the best known of the more accurate instruments. In experienced hands it gives excellent results, but the first cost is high, and owing to the number of different parts is liable to breakage, and a complete analysis requires from one to three hours. It is made in various forms consisting essentially of a measuring burette connected to a tube or bottle and containing a liquid—such as water or mercury—and a series of absorption pipettes in which the gas is brought successively into contact with the various reagents. By raising or lowering the leveling tube and manipulating the stopcock at the top of the burette, the gas sample can be drawn

in or expelled, successively passing into and being drawn back from the various pipettes to be measured before and

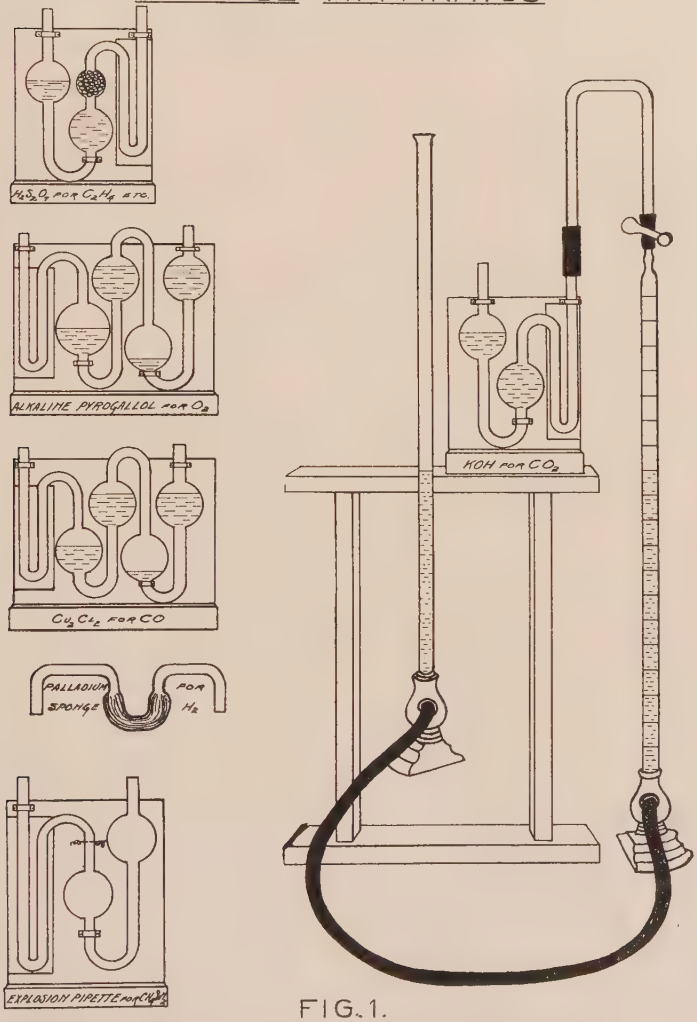


FIG. 1.

after the different absorptions. This type of apparatus has the advantage of being adapted to the use of mercury in-

stead of water as a sealing material, if analyses of water free gas are to be made.

The Orsat-Lunge apparatus (Fig. 2) is a variation of the Hempel and a convenient form of apparatus for the rapid and partial analysis of gas. It can be had in a wooden box, with removable front and back, and with a handle on the top so as to be readily transported, and analyses can be made on the spot. It consists of a measuring tube of 100 cc. capacity, which is surrounded by a water jacket for keeping the temperature constant. The base of this tube is connected to a leveling bottle, which is filled with water. The top of the measuring tube is joined by means of capillary tubing with three absorption vessels, which may be connected with, or shut off from, the measuring tube by means of stop-cocks. The outlet of each of these vessels is connected with a similar vessel in the rear furnished with a tubulated exit, which in turn is attached to a rubber bag, whereby air is excluded, and the reagent may be driven back if necessary.

The first vessel contains caustic potash, the second alkaline pyrogallic acid, and the third acid cuprous chloride solution. In order to increase the surface exposed to the gas, each tube is filled with narrow glass tubes set vertically, while in addition to these the cuprous chloride vessel contains pieces of copper wire which keep the solution reduced. In some forms of this apparatus there is a fourth vessel containing palladium sponge for the determination of hydrogen. The sample is measured and forced over into the vessel for absorption of carbonic acid, back to the burette for measurement, then into pyrogallic acid vessel for absorption of O_2 and back to burette, then into the acid cuprous chloride vessel for absorption of CO, from here into caustic potash vessel for the removal of acid vapors and thence to the burette and so on. In its ordinary form the Orsat apparatus does not admit of the determination of methane and hydrogen although some modern forms have an explosion pipette, and with this addition a complete analysis may be made.

In the second class the best known example is the Elliott

apparatus (Fig. 3), designed by Dr. A. H. Elliott of New York. In its original form and with its various modifica-

ORSATT-LUNGE APPARATUS

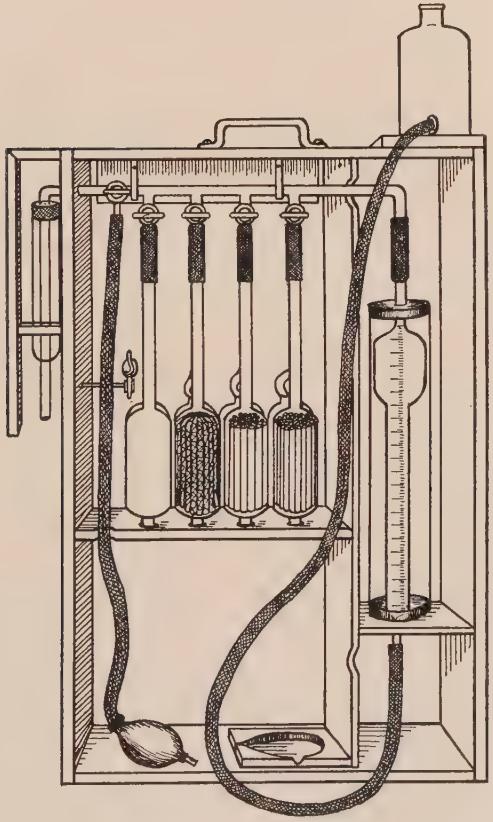


FIG. 2

tions it is intended for the rapid and complete analysis of coal, water or flue gases and is used to a very considerable

extent. It is probably not as accurate as the Hempel, but is much more rapid and less delicate, and, therefore, more suita-

ELLIOTT APPARATUS

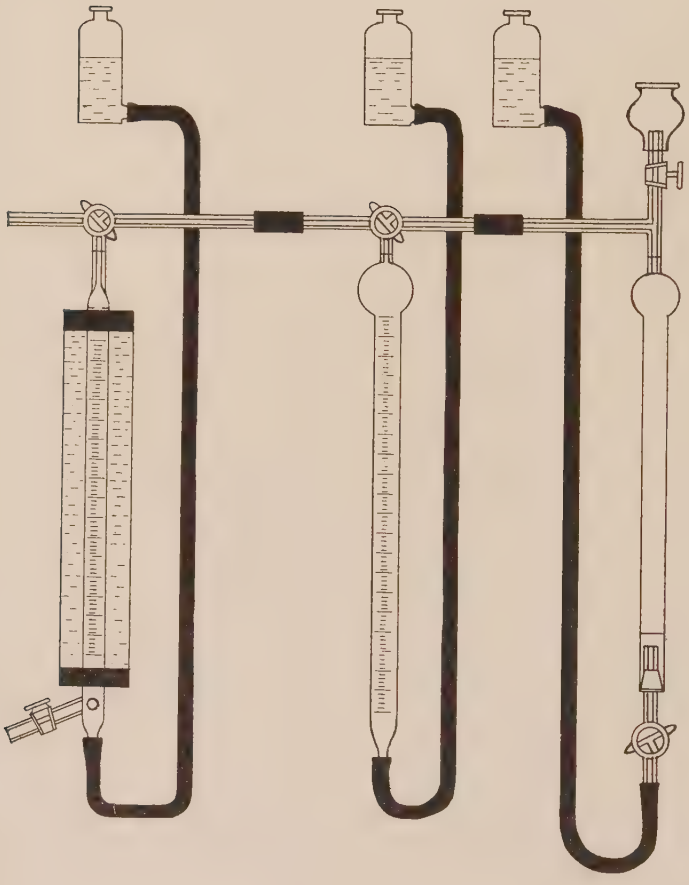


FIG. 3.

ble for rough work. It consists of three tubes, viz: laboratory, measuring and explosion tubes. The measuring burette

is surrounded with a water jacket to insure constant temperature and has a capacity of 100 cc. from the zero to the mark on the capillary tube, the graduations being in tenths of a cc. The gas is passed into the laboratory tube, then to the measuring burette to be measured, 100 cc. being taken. The reagents are introduced into the laboratory tube and the absorptions made in that tube, the gas being returned to the measuring burette after each absorption for measurement. After the use of each reagent in the laboratory tube the gas must be washed with water. The explosions are made in a third or explosion burette.

The Morehead apparatus (Fig. 4) belong also to the second-class, and consists of a single graduated, water-jacketed burette which is also provided with explosion points. The measuring, absorption, explosion and in fact the entire analysis being performed in the one burette, without necessity for movement of the sample. This apparatus is quite simple in design, economical in first cost, requires little training for its use and is quite rapid. As there is only the one burette, the necessity of shifting the sample is obviated, and an entire analysis of seven determinations can be made in from 30 to 40 minutes. Results obtained by different sets of this apparatus in the hands of different analysts working on the same gas, or results obtained by the same analyst working at different times on the same gas, are quite consistent and the calculations of calorific value from analyses made with this apparatus agree remarkably close with determinations of the calorific value made with a Junker's calorimeter.

It is not the intention of this paper, nor within its scope to suggest different lines or methods of gas analysis, or to suggest changes in the existing practice where such practice exists, or to draw comparisons between different designs of apparatus. There is practically only the one method and it is quite sufficient. With any of the modern types of apparatus consistent and valuable results can be obtained.

The object of this paper is to call attention to the value of gas analysis and to emphasize the importance of consist-

ently carrying it out. It is hoped by means of the explanations to enable gas men of average intelligence, but without

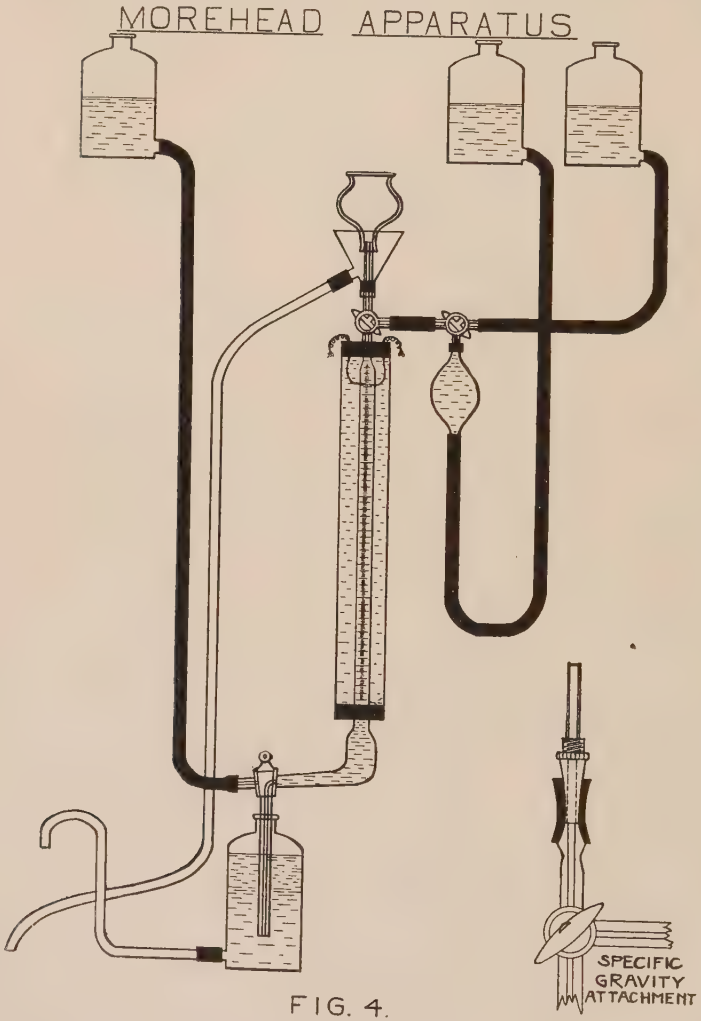


FIG. 4.

special analytical training to analyze their product, and further to simplify the manipulation and shorten the time so that the analysis of any gas may be incidental to a Superintend-

ent's daily work, and not the special duty of some one set apart for this purpose, also to furnish data and tables for the calculation of the heating value and for the intelligent interpretation of the results obtained from the analysis. In a word, to call attention to a most important but much neglected field of chemistry intimately related to the gas industry.

Constituents.

By analysis industrial gases are usually divided into their seven constituents, as follows: The order in which the constituents are given being that in which the determinations are made.

Carbon dioxide	CO_2
Illuminants	Ill
Oxygen	O_2
Carbon monoxide	CO
Hydrogen	H_2
Methane	CH_4
Nitrogen	N_2

These constituents exist in varying and in widely different proportions in different industrial gases, and in the same industrial gas proportions vary from day to day and with every change of operation of oil or fuel or of material. The characteristics of these constituents vary widely, but they may be grouped into a number of classes. Three of them—O_2, H_2 and N_2,—are chemical elements, two—CO_2 and CO—are combinations of C and O; two—CH_4 and the Ill—are a combination of C and H. Five of the seven—O_2, CO, H_2, CH_4 and N_2—are permanent gases, one—CO_2—is usually termed a gas, but as it can be liquefied at ordinary temperatures it must be classified as a vapor, while one—Ill—consist of part permanent gases and part vapors. Four of the seven—Ill, CO, H_2 and CH_4—contribute all of the lighting and heating value, while three—CO_2, O_2 and N_2—will not burn, are direct impurities and detract from the thermal and illuminating value made up by the other four. Of the four—Ill, CO, H_2 and CH_4—which form

the bulk of a gas and give it its value, two—CO and H_2—burn with a rather low heating value and no light, one—CH_4—contributes very largely to the heating value but does not raise the candle-power, while one—Ill—increases the heating value and contributes practically all of the open flame illuminating value.

Separately considered, these constituents exhibit the following principal characteristics: (Note Paragraphs on Air and on Acetylene being added.) All figures given are for dry gases at 60° F. and 30″ of Mercury.

The percentages are for volume—not weight—and, where the same applies, for combustion in air—not Oxygen—.

Carbonic Acid or Carbon Dioxide.

Formula ..... CO_2
Composition by weight ..... 72.73° O 27.27 C
Density or specific gravity, Air=1 ..... 1.519
Lbs. per cubic foot 0.1162
Cubic feet per lb. 8.606
Cubic feet air necessary to consume one cubic foot ..... Non-combustible
Gross B. t. u. per cubic foot ..... Non-combustible
Solubility, vols. absorbed in 1 vol. water. 1.005.

CARBON DIOXIDE OR CARBONIC ACID is one of the commonest of all gases. It is the product of combustion, of fermentation, of decay, of putrefaction, or of animal or human respiration in the presence, if not of an excess, certainly of a sufficiency, of air or of oxygen. Carbon dioxide occurs in the air to the extent of about five parts in 10,000 unless the air is polluted, then the proportion is higher. CO_2 is the gas which absorbed in water gives soda or sparkling water. It is also the "After Damp," "Choke Damp" or "Black Damp" found in mines after an explosion. While small quantities of this gas are not poisonous and may be taken into the stomach or into the lungs with impunity, 0.1 per cent of CO_2 in air is about the limit for breathing with comfort, 5 per cent will cause headache and languor, 4 per cent

to 6 per cent. will effect a candle flame, 8 per cent. to 10 per cent will eventually cause death from suffocation, 12 per cent to 15 per cent. will extinguish a candle flame.

In CO_2 the carbon has all of the oxygen with which it can combine, it is already completely burned and incapable of further combustion.

Carbon dioxide is an impurity and its presence is a detriment to any industrial gas which is intended for further burning. Air added to the gas before the gas is out of the fire will increase the CO_2, or steam which passed through the fire will produce CO_2 in a water gas process by reaction with the CO. Its presence shows that some of the gas or of the fuel is already consumed, and in a way CO_2 in a gas is analogous to ashes in a coal pile. Owing to its high specific heat CO_2 will lower the candle-power of illuminating gas between 2 per cent. and 4 per cent. for each 1 per cent. present.

Carbon dioxide is an acid and almost any alkali will absorb, neutralize and remove it. Potassium hydroxide is the best absorbent unless very small quantities of this gas are being dealt with, as in air analysis, or where extreme accuracy is required, when the more expensive barium hydroxide is to be preferred.

Illuminants or Heavy Hydrocarbons.

(See pages 327 and 328.)

FORMULA	Ethylene C_2H_4
Composition by weight	Ethylene 85.62% C 14.38 H
Density or sp. gr., Air=1	Ethylene 0.985
Lbs. per cubic foot	Ethylene 0.074
Cubic feet per lb.	Ethylene 13.38
Cu. ft. air necessary to consume one cu. ft.	Ethylene 14.34
Gross B. t. u. per cu. ft. (See paragraph on calculation, p. 327)	
Solubility, vols. absorbed in 1 vol. water	Ethylene 0.15

"Illuminants" is a term used to designate a group of dif-

ferent gases and vapors, and is unlike carbon dioxide, carbon monoxide, etc., which refer to single definite chemical compounds.

Illuminants are derived for the most part from the decomposition or "cracking" due to the moderate heating of organic compounds or mixtures, such as coal, petroleum, oils, fats, resins, etc., and to a large extent consist of so-called "unsaturated" compounds, or compounds which have the ability to unite or add to themselves certain elements or other compounds.

"Heavy hydrocarbons" are mainly dense and complex combinations of carbon and hydrogen which upon being heated readily break up into hydrogen and relatively large amounts of carbon. The carbon set free by the illuminants in a gas flame is to a great measure the cause of luminosity or candlepower of that flame.

The heavy hydrocarbons are for the most part poisonous if inhaled or swallowed, but they vary so widely among themselves that no definite figures can be given as to the percentages which carry toxic properties. It may be said of them, however, that in their physiological effect they resemble the vegetable rather than the mineral poisons, *i.e.*, the effect is soporific or stupifying rather than violently active, as is the case of carbon monoxide or cyanogen.

Illuminants vary in percentage in any one gas, and differ widely in composition and in characteristics in different gases. The illuminants of a carburetted water gas consist mainly of ethylene with other members of the olefine series and various other complex hydrocarbons existing either as gases or vapors. The illuminants will also vary in percentage and in composition in the same gas upon standing, on account of the fact that many members of the family in such a gas are vapors which gradually condense into liquid form and hence change the general quantity and nature of the residual mixture of heavy hydrocarbons.

Either ether, turpentine, petroleum, olive oil, fuming sulphuric acid or bromine will each absorb illuminants and may be used

for this purpose, but the last named is the most satisfactory.

Acetylene behaves as an illuminant and when it is pure bromine will absorb 100 per cent. of it.

OXYGEN.

FORMULA ..... O_2
Composition by weight ..... 100% O_2
Density or specific gravity, Air=1 ..... 1.105
Lbs. per cubic foot 0.0845
Cubic feet per lb. 11.83
Cubic feet air necessary to consume one cubic foot ..... Non-combustible
Gross B. t. u. per cubic foot ..... Non-combustible
Solubility, vols. absorbed in 1 vol. water..0.039

OXYGEN occurs free and forms 23.2 per cent. by weight and 20.8 per cent. by volume of the atmosphere—the rest being nitrogen—and it is the supporter of combustion and of animal and of vegetable life. Straight oxygen of 100 per cent. purity may be breathed without deleterious effect other than temporary giddiness and headache from over stimulation. While air containing as low as 7½ per cent. of oxygen —the remainder being pure nitrogen—will sustain human life. (See paragraph on air.)

Free oxygen found in gases in almost every instance comes from air which is mixed, intentionally or otherwise, with the gas, and when from this source it carries along with it four times its volume of inert nitrogen. The presence of oxygen itself is not detrimental to a gas, in fact, if the quantity of oxygen was not sufficient to carry an explosive hazard, its presence would be a benefit. A mixture of pure oxygen with gas would give a sharper, cleaner explosion in a gas engine, would have a higher candle-power in an open flame burner, and a much higher flame temperature and candle-power when used with a mantle than would the same gas without oxygen, but oxygen keeps very bad company and of the fourfold volume of nitrogen with which it is always accompanied, and of whose presence it is an indication, not one single word of commendation can be said.

It is almost impossible to get any industrial gas absolutely free from oxygen. This element along with its partner may come into gases from air dissolved in the water, or in the oil used in the processes, or from air held in the pores or interstices of the fuel, bricks, carbide, purifying material, etc. The presence of considerable quantities of free oxygen, if accompanied by nitrogen in approximately the proportion of air, is always evidence of an air leak, or of the use of excessive quantities of air, though the absence of free oxygen does not necessarily imply that there is no such leak because oxygen is so energetic that it may be absorbed, or if mixed before the gas is cooled below its ignition point it will combine with hydrogen and disappear as water vapor, or combine with the carbon and appear as carbonic acid or carbonic oxide leaving the nitrogen.

A high percentage of oxygen is an indication of a leak after the gas has passed out of the hot parts of the process, or the use of too much air for purification or for other purposes, or what is very often the case of carelessness in taking the sample or in performing the analysis. Oxygen may be absorbed by yellow phosphorus, or by an alkaline solution of pyrogallic acid, of which the latter is the better.

CARBONIC OXIDE OR CARBON MONOXIDE.

FORMULA .....CO
Composition by weight .....42.85% C 57.15% O
Density or specific gravity, air = 1....0.967
Lbs. per cubic foot 0.07394
Cubic feet per lb. 13.53
Cubic feet air necessary to consume one cubic foot 2.38
Gross B. t. u. per cubic foot 323
Solubility, vols. absorbed in 1 vol. water 0.0256

CARBON MONOXIDE OR CARBONIC OXIDE found in gases comes from the incomplete combustion of fuel. If there is a sufficiency of air almost every fuel will burn to CO_2, water and ash, while a deficit of oxygen results in partial combustion of carbon to CO instead of in complete com-

bustion to CO_2. The CO thus produced is half burned carbon and will burn to CO_2 if subsequently supplied with additional air or oxygen and ignited. CO is produced also if a gas flame, either luminous or bunsen, comes in contact with a cold or a sooty surface.

CO is the poisonous constituent of gases, 0.05 per cent. being sufficient to cause giddiness, 0.1 per cent. will bring about inability to walk, 0.2 per cent. loss of consciousness and 1 per cent. will produce death after a few minutes of inhalation.

CO like hydrogen is valuable principally on account of the volume which it gives to an industrial gas, and as a carrier for the vapors, etc., forming the illuminants. It possesses no candle-power but its 323 B. t. u. per foot contributes to the calorific value.

In gases for burning, a high percentage of CO is evidence of good working conditions, especially if there is at the same time little or no CO_2.

The best absorbent for carbon monoxide is a hydrochloric acid solution of copper monochloride.

Hydrogen.

FORMULA	H_2
Composition by weight	100% H
Density or specific gravity, air = 1	0.0692
Lbs. per cubic foot	0.005321
Cubic feet per lb.	187.9
Cubic feet air necessary to consume one cubic foot	2.39
Gross B. t. u. per cubic foot	326
Solubility, vols. absorbed in 1 vol. water	0.019

HYDROGEN is a metal and is the lightest of all known substances. It does not exist free in nature. In industrial gases it is produced by the breaking up of water by hot carbon or by the excessive heating of some of the hydrocarbons introduced in the shape of oil or coal for the purpose of adding illuminants, or by the action of some acid on certain metals. Excessive temperatures in a gas machine

will result in the breaking down of any illuminant or other hydrocarbon into lampblack and hydrogen.

The presence of steam in the carburetter or superheater of a water gas machine, or of wet coal in a retort, will produce hydrogen by combination with CO according to the formula: $CO + H_2O = CO_2 + H_2$.

Like CO hydrogen adds to the volume of a gas and acts as a carrier of the other constituents. It is without candle-power itself but its 326 B. t. u. per cubic foot contributes to the calorific value.

Hydrogen is without physiological effect and probably stands next to nitrogen for inertness from this standpoint.

There is no satisfactory liquid absorbent for hydrogen. To determine its percentage it is caused to burn in an excess of oxygen with which it combines to the extent of one-half its volume and forms water—H_2O—this condenses and from the contraction the percentage of hydrogen is calculated.

Hydrogen can be determined also by use of a "Palladium Tube"—see p. 295. This method has to be used where the gas has in addition to methane, ethane or other bodies of the methane series which have to be separated from the methane. It is also useful as a check on the other method, but for ordinary use it is too cumbersome and costly, and requires too long a time and too high a degree of analytical ability to make it preferable to the explosion method.

METHANE OF MARSH GAS.

FORMULA	CH_4
Composition by weight	74.86% C 25% H
Density or specific gravity, air = 1	0.553
Lbs. per cubic foot	0.04233
Cubic feet per lb.	23.62
Cubic feet air necessary to consume one cubic foot	9.5617
Gross B. t. u. per cubic foot	1009
Solubility, vols. absorbed in 1 vol. water	0.0386

METHANE OR "MARSH GAS." In industrial gases this constituent comes from the distillation of oil or of coal

at fairly high temperatures. This hydrocarbon is the active element of natural gas and of "Fire Damp" found in mines, and was probably produced at some remote geological period when measures of soft coal or oil deposits were subjected to excessive temperatures. It is produced in nature by decay out of the presence of oxygen or of air, such as the slow decay of animal or of vegetable matter under water, hence the name of Marsh gas.

Methane is without physiological effect and mixtures of it in air up to even 45 per cent. to 50 per cent. may be breathed and the discomfort experienced even then is probably more due to the want of oxygen than to the presence of methane.

After the illuminants have been distilled off of oil or of coal, or when the temperatures are too high for their production methane is produced, or it may result from a partial breaking down of illuminants due to excessive temperatures which are not quite high enough to effect complete decomposition into lampblack and hydrogen. Methane having a c-p. of from 2 to 7 does not add especially to the illuminating value of a gas but owing to its high calorific value it is of very great value in raising the B. t. u. of any gas in which it appears.

There is no known absorbent of methane but when this hydrocarbon combines with oxygen it produces its own volume of CO_2 which may be subsequently absorbed by KOH, and from the contraction the volume of methane originally contained may be calculated

NITROGEN.

FORMULA	N_2
Composition by weight	100% N
Density or specific gravity, air = 1	0.971
Lbs. per cubic foot	0.07413
Cubic feet per lb	13.49
Cubic feet of air necessary to consume one cubic foot	Non-combustible
Gross B. t. u. per cubic foot	Non-combustible
Solubility, vols. absorbed in 1 vol. water	0.015

NITROGEN is the dead, inert, effete or worn out member of the family of elements. It exists free in nature, forming 77 per cent. by weight and 79 per cent. by volume of the atmosphere, the rest being oxygen. It is not poisonous, but will not support life or combustion. Straight nitrogen of 100 per cent. purity may be inhaled with perfect impunity until distress comes about from want of oxygen, or nitrogen may be swallowed or injected into the cavities of the body without effect. Nitrogen has only a few combinations with the other elements, and can not be made to form these without a good deal of difficulty, and when it is in combination it comes out with great emphasis upon very small provocation. Practically all modern explosives consist of nitrogen held in some form of unstable combination, and a dynamite, nitro-glycerine, gun-cotton, or gunpowder explosion is nothing more or less than this element dissociating from some unwilling union.

Nitrogen is not affected by extremes of temperature, or by ordinary chemical reagents. It passes into the stomach or lungs of animals, or into the fire of the gas engine, gas furnace, or of a gas burner as nitrogen and comes out again as nitrogen. In the analysis of gases every other constituent is absorbed, dissolved or burned, and what is left unchanged after the drastic treatment with a number of diverse chemicals and an explosion with pure oxygen is nitrogen.

The presence of some nitrogen in gas is unavoidable and like oxygen is usually evidence of air. Nitrogen like other incombustible impurities in gas lowers the calorific value just in proportion to its presence, but effects the candle-power to a greater extent. It may come from the same sources as those mentioned for oxygen, or in coal or in water gas is left from the air added for purposes of revivification. As there is no practical absorbent for nitrogen it is determined by difference; the difference between the sum of the percentages of the other constituents and 100 is taken to be the percentage of this element. (See paragraphs on oxygen and on air.)

Air.

FORMULA ..... Mixture O_2 and N_2
Composition by weight..... 76.83% N_2 23.17% O_2
Density or specific gravity, air=1.... 1.000
Lbs. per cubic foot 0.07657
Cubic feet per lb. 11.91
Cubic feet air necessary to consume one cubic foot ..... Non-combustible
Gross B. t. u. per cubic foot ..... Non-combustible
Solubility, vols. absorbed in 1 vol. water 0.0178

AIR is a mechanical mixture of oxygen and nitrogen. It usually contains small and varying percentages of moisture, dust, CO_2 and other impurities, though not in quantities which may be detected without special apparatus and methods.

An analysis of a typical sample of mountain, or of sea air would be about as follows:

	Per cent.
Nitrogen, N_2	78.35
Oxygen, O_2	20.77
Water vapor H_2O	0.83
Carbon dioxide, CO_2	0.05
	100.00

Deducting the H_2O and CO_2 we would have:

Oxygen	by volume 20.96%	By weight	23.17%
Nitrogen	by volume 79.04%	By weight	76.83%

The ratios of the constituents by volume are:

Vol. oxygen $\times$ 4.77 = vol. air
Vol. oxygen $\times$ 3.77 = vol. nitrogen
Vol. nitrogen $\times$ 1.26 = vol. air
Vol. nitrogen $\times$ 0.265 = vol. oxygen
Vol. air $\times$ 0.791 = vol. nitrogen
Vol. air $\times$ 0.209 = vol. oxygen

No exact figures can be given which indicate definitely the

proportion of the deficit of oxygen or the content of CO_2 in air at which point the air becomes dangerous to breath.

If the oxygen is abstracted chemically, or pure CO_2 added, mixtures covering a very wide range indeed may be inhaled with impunity. But oxygen is almost invariably extracted and CO_2 added by some process by which other impurities are added at the same time, and these are very apt to render the air unfit for breathing before this condition would become evident from an analysis showing merely the oxygen, nitrogen and CO_2 content of the sample taken. From a hygienic standpoint, however, it is always wise to regard with grave suspicion any air showing from 0.5 per cent. to 2 per cent. of CO_2 or 5 per cent. less than the normal amount of oxygen, while air showing as much as 5 per cent. of CO_2 or any appreciable percentage of any other impurity—especially CO—is positively poison.

Air effects the calorific value of a gas as do other noncombustible impurities, just to the extent and in direct proportion to the percentage present, but like the other impurities in the same class it effects the candle-power to a far greater extent. Comparatively low candle-power illuminating gases such as coal gas of about 16 c-p. suffer more from an air admixture than does a higher c-p. water gas. One per cent of air mixed with coal gas will take off about 8 per cent. of its candle-power, 4 per cent. of air 25 per cent., and 45 per cent. of air will render the flame practically nonluminous.

With a good quality of water gas of 25 candle-power the admixture has a fairly constant effect of removing from 2 per cent. to 2.5 per cent. of the candle-power for each 1 per cent. of air present.

The analysis of air for its three constituents which may be determined by ordinary methods, and with ordinary apparatus, consists of the absorption of CO_2 with KOH, or with barium hydroxide, and of the oxygen by pyrogallate of potassium or with yellow phosphorous, the nitrogen being the difference. (See paragraphs on CO_2 and on oxygen.)

Acetylene.

FORMULA ..... C_2H_2
Composition by weight .....92.29% C 7.71% H
Density or specific gravity, air = 1..... 0.898
Lbs. per cubic foot 0.0687
Cubic feet per lb. 14.56
Cubic feet air necessary to consume one cubic foot 11.91
Gross B. t. u. per cubic foot.....1474
Solubility, vols. absorbed in 1 vol. water 1.11

ACETYLENE is an absolutely fixed, definite, chemical combination of carbon and hydrogen. It may be prepared in a state of chemical purity and in this respect differs from all other artificial illuminants. Acetylene is without physiological action and may be inhaled or swallowed with impunity just as could be hydrogen or nitrogen. Except for possibly traces in Coal Gas, Acetylene does not occur in ordinary gases, and in America it is never mixed with other industrial gases. In its commercial form it is rarely free from 2 per cent. to 8 per cent. admixture of air which comes into it from the water in the generator, or is introduced when the generator is charged, or comes from the interstices of the carbide. In chemistry acetylene behaves as an illuminant and may be absorbed with either an ammoniacal solution of cuprous chloride or with bromine, the latter is the better. (See paragraph on illuminants.) For the determination of the air contained in acetylene see paragraphs on oxygen and on air.

Method of Gas Analysis.

In order that this paper may serve as a text-book for those desiring to undertake this form of investigation, the following instructions, notes, tables, etc. are incorporated. These instructions apply specifically to the type of apparatus in use for the past six years in the laboratories of The Peoples Gas Light & Coke Company of Chicago, and by a number of other gas companies. The tables, deductions, etc. are built upon deductions drawn from results obtained with this apparatus.

The seven constituents which compose most industrial gases, and which are ordinarily analyzed for, are:

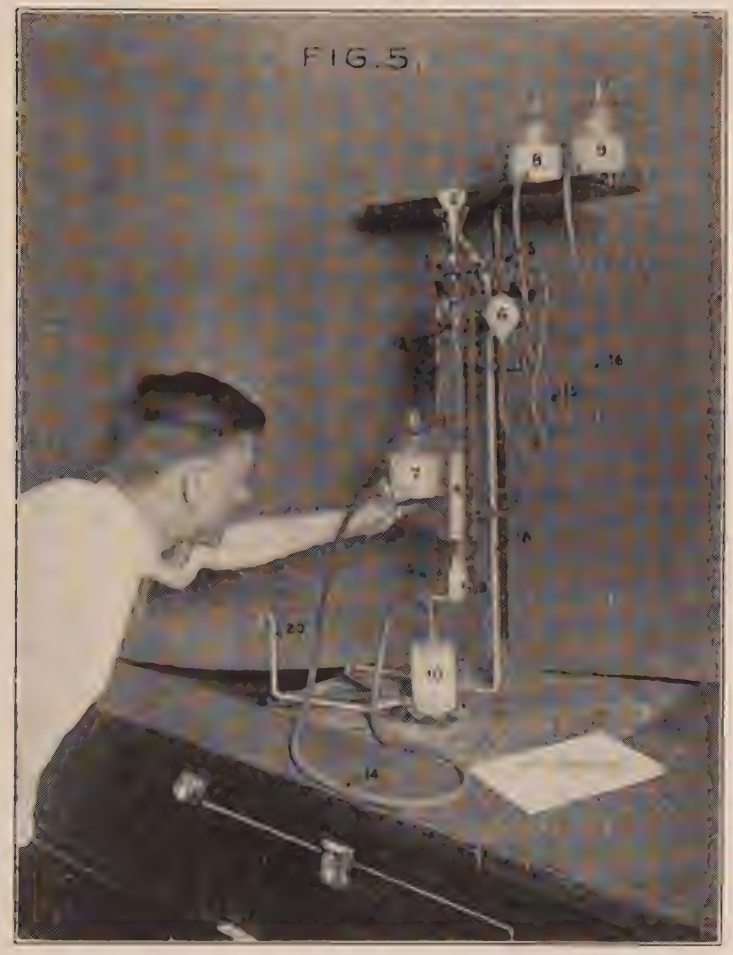
Carbonic dioxide ..... CO_2
Illuminants ..... Ill.
Oxygen ..... O_2
Carbon monoxide ..... CO
Hydrogen ..... H_2
Methane ..... CH_4
Nitrogen ..... N_2

Of these, the first four are determined by absorption, the next two by explosion and the last by difference.

The gas analyzing apparatus as shown in Fig. 5 consists of a graduated burette (4) fitted with platinum electrodes (13) and a storage bulb (6). Three aspirator bottles (7, 8 and 9) with rubber tubing (14, 15, 16 and 17), and an electric sparking outfit are also required. Both glass pieces are fitted with three-way cocks (1, 2 and 3). The measuring, explosion, washing, and the entire analysis is made in the graduated burette; the bulb (6) is used only for storage of the reserve supply of gas after the CO absorption in case the explosion is unsatisfactory. The burette (4) is usually provided with a water-jacket (11) consisting of a large glass tube confining by large rubber stoppers at the ends clear distilled water. A bottle or beaker (10) is placed under cock (2) to form a seal and catch waste reagents and wash water. A removable funnel or cup (5) is attached to burette capillary tube at the top by a ground joint. A secondary funnel (12) beneath (5) serves to drain away excess reagent or wash water by means of drain tube (18).

In preparing the apparatus for an analysis, first fill the aspirator and seal bottles (8, 9 and 10) and the leveling bottle (7) with distilled water previously saturated at the temperature of the water-jacketed burette with the gas to be analyzed, and place aspirator bottles (7, 8 and 9) on shelf (21). By manipulating cock (3) displace all air from rubber tubing (15, 16 and 17) until water entirely free of bubbles

flows upward through ground joint into cup (5). Then open cock (2) to seal bottle (10) and purge all air out of tube (14) through cock (2) into seal bottle (10). Similarly open



cock (2) to burette (4) and fill same with water up to funnel. When the apparatus is quite full of water, as described, remove cup (5), open cock on sampling can or pipe from which the sample is to be taken, allow the gas to blow

through the hose for a few seconds to insure the expulsion of all air, and then attach hose to the ground joint end of the capillary tube at the top of the burette. Turn cock (2) so that the water in burette (4) communicates with the leveling bottle (7), held level with funnel (5). Now open cock (1) so that the gas sample enters burette only, and as the surface of water in the burette (4) is depressed, slowly lower the leveling bottle (7), keeping the surface of water in same slightly above that in the burette in order to insure no inward leaks of air through loosely attached tubing, etc. When the gas has displaced nearly all water to about a point (19) in the burette, close cock (1), remove rubber tubing at top of burette and replace cup (5). Open cock (3) for a few seconds and expel gas from capillary tubes until water flows into cup (5) and fills it about one-quarter full. If the sample is taken from the house piping, or where there is an abundant sample, it is well to allow the gas to flow entirely through the burette and out at the lower stop-cock for a few seconds, care, of course, being taken to purge out excess gas from stem of cock (2) into bottle (10) before securing the 100 cc. sample for analysis.

If the gas sample be at a different temperature than the burette, allow it to remain in the burette for a few minutes before proceeding to secure the desired 100 cc. When the gas has assumed the temperature of the burette, raise leveling bottle (7) so that the water level is sufficiently above the 100 cc. graduation of the burette to force small bubbles of the confined sample through the water into cup (5), when the cock (1) is slightly opened. Bubble excess gas sample slowly outward in this manner until upon closing cock (1) and lowering bottle (7), its water level and that in the burette are at the 100 cc. mark. If the zero mark of the burette be at the cock (1), then the 100 cc. mark is taken for a leveling point as just described, but if the zero graduation be at the point of capillary retention, where the capillary tube immediately below cock (1) widens into the burette proper.

then excess gas is bubbled outward, until the water levels in the bottle (7) and burette (4) are at a mark equal to 100 cc., minus the previously determined volume (usually 0.3 or 0.4 cc.) of the capillary tube between cock (1) and the zero graduation at the point capillary retention. In the latter case, after adjusting the burette water level at 99.7 or 99.6, as the case may be, bottle (7) is placed on a level with (10) and the cock (1) is slightly opened until the water in cup (5) slowly enters the burette capillary tube at the top to the point of capillary retention, when it will be found upon raising bottle (7) that the water level corresponds with the one in the burette, which will be at the 100 cc. graduation.

When there is just 100 cc. in the burette the analysis may be started.

Turn the cock (2) so as to connect the burette with the bottle (10) raise the funnel (5) until it is just off of its ground joint and drain, leaving about ¼ in. of water in the bottom. Lower the funnel on to its seat and put into it about 20 cc. of potassium hydrate solution. Be sure that cock (2) is set so that the burette is connected with (10). Now open cock (1) and let the potassium hydrate solution *drain* very slowly into the burette. When it has nearly all gone into the burette close cock (1) and open cock (3) and let water from bottle (8) or (9) through into the funnel (5) for about ten seconds. Rinse the funnel and fill it with about 50 cc. of distilled water previously saturated with the gas being analyzed. Pass this wash water *slowly* through the burette, and when nearly all has entered burette, close cock (1). Wait two minutes for water to drain down the sides of the burette. Then turn cock (2) so that burette is connected with bottle (7), and read the contraction of the gas, at the same time holding the bottle (7) with the surface of the water in the bottle level with the surface of the water to the burette; also note the reading on the burette graduations coinciding with the bottom of the meniscus of the water level in the burette. The amount absorbed as indicated by the con-

traction in cc., or difference in cc., between the 100 and the burette reading, equals the per cent. of carbon dioxide.

Turn cock (2) to connect the burette with the bottle (10), and with a 1 cc. pipette put about two drops of bromine into the funnel (5) which should contain about 20 cc. of distilled water. Drain this *slowly* into the burette, as in the previous operation, until the entire gas space in the burette is filled with reddish brown bromine fumes, then admit the rest of the bromine and most of the water in the funnel. Next pour into the funnel about 30 cc. of potassium hydrate solution and drain part of this solution in slowly until the water ceases to rise and the burette and the surface of the water are quite free from bromine fumes. Wash with about 75 cc. of aerated distilled water. Wait two minutes and measure as explained above. The amount absorbed in cc. equals the per cent. of illuminants.

Now place in cup (5) about 20 cc. of pyrogallic acid solution, and add 20 cc. of KOH solution and allow mixing to take place naturally for about ten seconds, then drain this through, wash out the burette with about 75 cc. of distilled water and measure in the way previously explained, after waiting at least two minutes for gas to resume temperature of burette jacket. The resulting contraction in cc. equals the per cent. of oxygen.

Next place about 40 cc. of copper monochloride solution in the funnel and drain through very slowly until no further contraction is observed. Then if no reagent remains in cup (5) add 10 cc. of same reagent and pass it through the burette. Pass in about 50 cc. of distilled water and after this 10 cc. KOH solution, drain through and wash out with about 100 cc. of distilled water. The amount absorbed in cc. equals the per cent. of carbon monoxide. This reagent should be added rather slowly and several minutes allowed for its action on the CO.

The carbon monoxide is the last constituent to be deter-

mined by absorption. Of the remaining three, two must be determined by an explosion and the third by difference.

Make a careful note of the reading of the burette after the CO absorption, as this figure has to be used in the H_2 and CH_4 calculation.

Turn cock (2) so as to give connection between bottle (7) and burette, and cock (3) so as to connect (7) through burette (4) and bulb (6) with (8). Place (8) on the table level with (10) and hold (7) so that its water level is opposite the graduation indicating 10 cc. Now open cock (1) carefully and allow gas to pass very slowly through cocks (1) and (3) into the storage bulb (6). When all but exactly 10 cc. has passed into the bulb (6) close cocks (1) and (3) and place bottle (7) on a level with (10). Pass a little water from (9) directly into the cup (5) so as to get all of the gas out of the passages between the bulb (6) and the cup (5). Also open cock (1) slightly and allow water to pass from cup (5) into burette to zero mark. By manipulating (7) have the amount of gas in the burette exactly 10 cc. A small excess may be gotten rid of through cock (1) and the funnel (5). Turn cock (2) so as to connect burette (4) and bottle (10): remove funnel (5) and connect oxygen hose to top capillary tube. Then open cock (1) and let about 20 cc. of oxygen enter. Remove oxygen tubing and allow about 10 cc. of air to enter burette, exact proportion of oxygen and of air admitted to burette are not essential. Close cock (1), allow water to pass from (9) through (3) and (1) into cup (5), and with bottle (7) lowered, open cock (1) until water passes into burette to zero mark. Then read contents of the burette accurately. The quantity of the mixture in the burette should be in the neighborhood of 40 cc. Attach wires to the electrodes on the sides of the burette, turn cock (2) so that the burette is connected to the bottle (7), see that tubing is straight and cause a spark to pass between the electrodes. After the explosion allow the gases to stand at least three minutes before reading the burette. Measure the contraction.

This contraction is known as the "1st. contraction." Make a note of this, then place about 20 cc. of potassium hydrate solution in the funnel (5) and drain the burette. Wash with about 100 cc. of air saturated distilled water and measure. The contraction due to absorption by the KOH solution is known as the "2d contraction." The amount of gas left after the absorption for CO, divided by the amount taken for the explosion, is called the "constant."

The amount of hydrogen in the original mixture is equal to the first contraction multiplied by two, minus four times the second contraction divided by three and multiplied by the constant.

FORMULA FOR H_2

Per cent. by vol. of H_2 =

$$\frac{2 \times (\text{1st contraction}) - 4 \times (\text{2d contraction})}{3} \times \text{constant.}$$

Per cent. by vol. of CH_4 = 2d contraction $\times$ constant.

The above formula is volumetric, not gravimetric, and is based on Avuagadro's law which states:—"Under the same conditions of temperature and of pressure equal volumes of all gases contain the same number of molecules." Since the analyses are made under the same conditions of temperature and of pressure, this law applies.

A clearer understanding of the derivation of the formula can probably be had by a graphic representation, and Fig. 6 is referred to.

Consider A, B and C to be the burette, A being before the explosion, B being after the explosion, and C after the second contraction. According to the formulæ:

$$H_2 + \tfrac{1}{2}O_2 = H_2O$$

and

$$CH_4 + 2O_2 = CO_2 + 2H_2O.$$

Two volumes of H_2 will combine with one half volume of O_2 and leave no residue which will occupy space in the burette. That is to say, that for every two volumes of hydro-

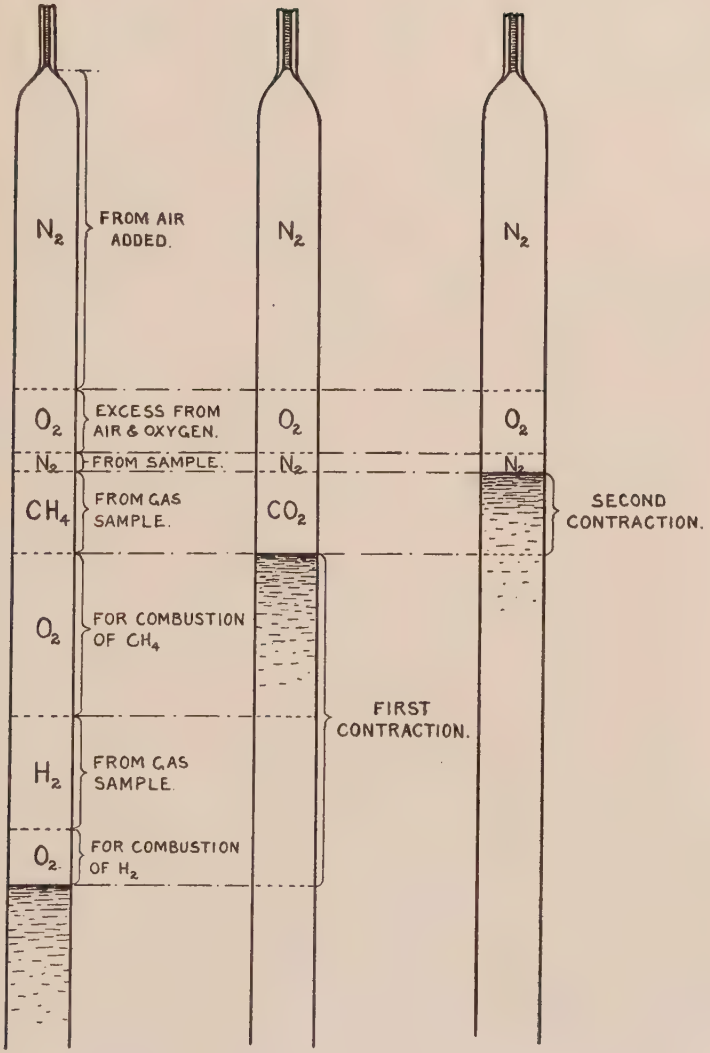

N2
FROM AIR ADDED.
O2
EXCESS FROM AIR & OXYGEN.
N2
FROM SAMPLE.
CH4
FROM GAS SAMPLE.
O2
FOR COMBUSTION OF CH4
H2
FROM GAS SAMPLE.
O2
FOR COMBUSTION OF H2
N2
O2
N2
CO2
FIRST CONTRACTION.
N2
O2
N2
SECOND CONTRACTION.
A.
B.
C.

FIG. 6.

gen consumed, three volumes disappear of which two volumes were hydrogen and one was oxygen. Or in other words, two-thirds of a contraction due to an explosion of the hydrogen was hydrogen.

Now a given volume of methane when burned produces its own volume of CO_2 but at the same time causes the disappearance of two volumes of O. That is, there will be as much CO_2 after the explosion of the methane as there was of methane before the explosion, but twice this volume of oxygen will have disappeared. Or there will be a disappearance as contraction due to combination of the oxygen with the hydrogen of the methane equal to twice the volume of the original methane.

Thus after the explosion the only thing left in the burette to represent the original hydrogen and methane is a certain volume of carbon dioxide equal to the original volume of methane, all of the hydrogen along with two and one-half volumes of the excess oxygen having disappeared.

If there was no methane at all present the percentage of hydrogen in the original mixture would be equal to two-thirds of the contraction due to the explosion of the hydrogen, but at the same time that there is a contraction due to the combination of the hydrogen with oxygen. Here is also a contraction due to the combination of the methane with oxygen, and hence the first contraction is a gross contraction due to the combination of both the hydrogen and the methane. The next step is to determine what proportion of this gross contraction is due to the hydrogen and what to the methane.

We have seen that for every volume of carbon dioxide present before the absorption with KOH that two volumes of oxygen have disappeared. The "second contraction" gives us this volume of carbon dioxide so that by multiplying it by two we get the total contraction due to the methane, and subtracting this from the gross contraction due to the hydrogen and the methane, we get the net contraction due to the hydrogen alone, two-thirds of which would be the volumetric

percentage of this hydrogen in the portion taken and this multiplied by the "constant" gives the percentage in the original gas.

The volume of carbon dioxide as given by the second contraction is equal to the volume of methane in the portion of the sample exploded, which multiplied by the "constant" gives the percentage in the original gas.

The constituent which we call "methane"—CH_4—often contains in addition ethane—C_2H_6—, especially in rich gases and in natural gas from wells which are approaching exhaustion.

The ethane present is burned in the explosion and is reported as methane increasing the per cent. of methane slightly, and lowering to the same extent the percentage of hydrogen and of nitrogen, but in ordinary work and in the calculation of the calorific value of a gas the effect of the presence of small quantities of ethane is negligible.

Ethane may, however, be readily determined separately if it is desired. The hydrogen must first be separately removed by means of a palladium tube. This is done by adding to 10 cc. of the residual gases oxygen and air just as directed above for the explosion.

The palladium tube is installed between the burette and the storage bulb. A beaker containing water, which is kept at the boiling-point by a Bunsen lamp, is so placed as to have the loop of the tube immersed in the hot water. An accurate reading of the amount of mixture is then taken and the mixture passed very slowly through the tube into the storage bulb and then back. Care must be taken not to pass the gas through the tube too rapidly, or the heat generated is apt to break up some of the methane. The palladium does not really absorb the hydrogen from the mixture, but by a catalytic action causes it to combine with the oxygen present and form water, and hence two-thirds of the contraction due to passage of the mixture over the palladium is the percentage of hydrogen. The known volume of mixture after the hydrogen absorption is then exploded and the contraction noted.

A second contraction due to the absorption of the carbon dioxide by KOH formed is also noted.

The volumes of the methane and ethane may then be calculated from the following formulæ; where

First contraction, due to condensation of water vapor formed, and

Second contraction, due to absorption of carbon dioxide formed.

Per cent. by vol. of CH_4 =

$$\frac{4 \times (\text{1st contraction}) - 5 \times (\text{2d contraction})}{3} \times \text{constant.}$$

Per cent. by vol. of $C_1H_6 = C_2H_6$

$$\frac{4 \times (\text{2d contraction}) - 2 \times (\text{1st contraction})}{3} \times \text{constant.}$$

The difference between the sum of all the percentages found by the above determinations and 100 is the percentage of nitrogen.

Solutions:

1. The potassium hydrate, or hydroxide solution, is made by dissolving 5 parts by weight of chemically pure potassium hydroxide (purified sticks) in 100 parts by weight of distilled water. This solution should be kept in well stoppered bottles using rubber stoppers to prevent sticking and deterioration of solution due to absorption of carbon dioxide from the air. The same hydrate solution is used for the absorption of CO_2, of bromine fumes and with the pyrogallic acid for oxygen, and of CO_2 after methane. The hydroxide which comes marked "Pure by Lime" is better for this use than that marked "Pure by Alcohol."

2. The pyrogallic acid solution is made by dissolving 10 parts by weight of chemically pure pyrogallic acid in 100 parts by weight of distilled water. To every 1,000 parts by weight of this solution add 5 parts by weight of oxalic acid as a preservative.

Do not mix the pyrogallic acid solution with the potassium hydrate solution except in the funnel and until quite ready

for use, as the potassium pyrogallate thus formed will absorb oxygen from the air and lose its strength. At least two minutes should be given the oxygen absorption with potassium pyrogallate when flue gases or engine exhaust is being analyzed.

3. The copper monochloride solution is made by dissolving 75 parts by weight of chemically pure copper monochloride in 720 parts by weight of concentrated hydrochloric acid, to which has been added 400 parts by weight of distilled water. Ten or twenty grams or more of clean bare copper wire or foil should be added and kept constantly in the bottle with the mixture to prevent deterioration. When a small quantity of the solution is added to a large amount of water a cloudy white precipitate of copper monochloride appears. When no cloudiness is thus produced, and the mixture shows a blue tint, the preparation has become oxidized and is unreliable.

4. Gas saturated distilled water may be prepared by means of the apparatus shown in (Fig. 7) at a temperature not less than, and preferably a few degrees above, that at which it is to be used so as to avoid evolution of the dissolved gases in the burette.

5. Distilled water may be sufficiently aerated by shaking it vigorously for two or three minutes in a large bottle three-quarters full of distilled water.

Apparatus:

6. The apparatus may be cleaned from time to time by running through it a solution of potassium bichromate in sulphuric acid. This is useful when the platinum points become coated with carbon. This cleaning solution should be used with care, as sudden mixing of the sulphuric acid solution with the water in the burette generates considerable heat which may break the burette.

7. For constant use it is well to install the water-jacketed burette, as shown in plate, by means of clamps attached to a permanent pipe stand supporting a shelf over a sheet lead drain. The electrodes (13) leading from burette (4) are

insulated from water-jacket (11) by rubber tubing, containing copper wires fused to the platinum leads and leading to the terminals of a one-fourth inch spark coil, operated by at least two ordinary dry batteries, (not shown in plate). A drain funnel (12) connected by rubber tubing to a glass

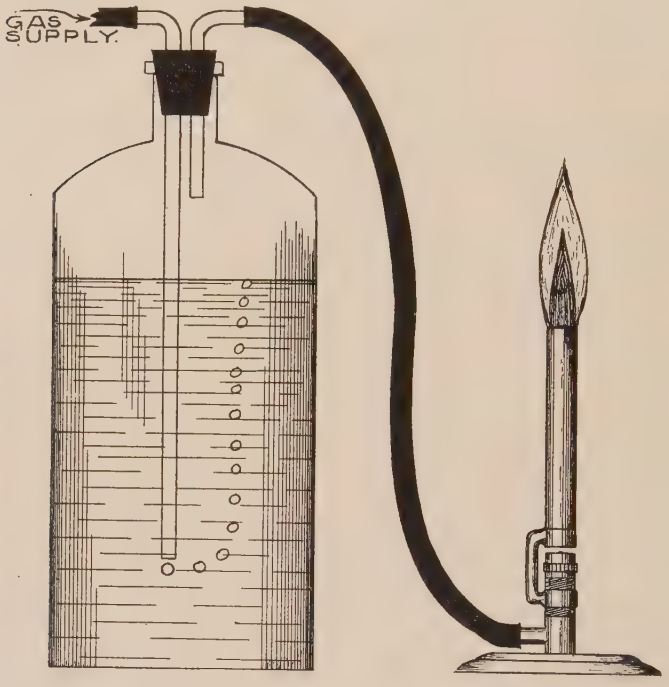


FIG. 7.

tube (18) of one-fourth inch bore extending to sink or drain pipe, will be found of great convenience in a permanent installation for getting rid of waste from funnel or cup (5). A drain tube (20) leading from bottom of bottle (10) upward and curved in a semi-circle at the top so that the outlet is level with the desired water level in the bottle (10), will be found advantageous in securing cleaniness.

8. Rubber tubing (14), (15), (16), and (17) should be of the heavy-wall, pure gum variety, and of such internal diameter as to give tight joints over the glass tubing, etc. The joints should be wired to insure freedom from leaks incident to loosely attached tubing.

9. By keeping the apparatus and all of the bottles filled with water, especially when not in use, and the reagent bottles in immediate proximity, the entire outfit acquires about the temperature of the room, and the error arising from the source of temperature changes in the sample is eliminated.

10. The explosions take place in the measuring burette. A coil which will give a one-fourth inch spark is ample. Too strong a spark is apt to crack the glass as is a continuous play of sparks between the points, or a play of sparks when the burette is dry. If the explosion does not occur simultaneously with the first spark, the spark need not be continued. Something else is wrong. The usual trouble is that the confined mixture is not an explosive one and the proportion of air or oxygen to gas residual must be changed.

11. The reagent funnel (5) and top ground joint of burette should be washed well after the completion of each analysis to prevent sticking at the ground joint, due to any potassium hydrate solution which may be present. This rule is applicable also to other movable parts such as cocks which are likely to stick.

12. The bulb (6) which is not graduated, is used to hold the excess of gas when the explosion is being made. The analyst occasionally loses an explosion, and were it not for the gas held in this bulb, the entire analysis would have to be made over. By putting into the bulb all of the gas that is left after the CO absorption, except the 10 cc. which is used for the explosion, several explosions may be made as checks on one another, or in case the first one is lost.

13. If the cocks stick, they can usually be loosened by a little hot water on the outside. They should be kept well lubricated with a mixture of equal parts of vaseline, tallow and paraffine.

14. For getting samples, it is best to get four sample cans. The sketch above will show what these are. In getting the sample the can is placed in an upright position and filled quite full of water, perfectly saturated with the gas to be sampled in order to expel all of the air. A tube connected with the upper stop-cock is then introduced into the space from which the gas sample is to be drawn, and the lower stop-cock is opened, allowing the water to run out and thus the sample is aspirated into the can. In drawing samples from places which have a suction instead of a pressure, such as the inlet of an exhauster, or at the base of a stack, or in the breeching of a boiler, the water should be allowed to flow out through a U-shaped glass tube attached by a piece of rubber hose to the lower stop-cock. If this is not done, after the water is all out, air will enter and spoil the sample. It is essential to draw out all of the water, even if only a small sample is required, as a number of the constituents, illuminants and CO_2 for example, are soluble in water. If the gas to be sampled is under pressure it is well enough to allow it to flow through the can for a few seconds after all of the water has run out.

To get the sample out of the can, the lower stop-cock is connected by a hose with a source of water under pressure such as an aspirator bottle filled with water and placed at a level above that of the sampling can, and as the water runs into the can the gas will be displaced and may be led by means of a hose to the burette.

15. The principal precaution necessary in gas analysis is to see that the temperature of the apparatus and of the water used, and of any additional water which may be added, as well as the temperature of the sample undergoing examination does not change during the analysis. A change of 5.2° F. will cause a change of about one per cent. in the volume of any gas at an ordinary temperature of 60° F. The temperature at which an analysis is made is immaterial but that temperature MUST remain constant.

16. In reading the burette, hold leveling bottle (7) in front and just to one side of the burette, so that the eye of the

analyst can sight along the under surface of the water level in (7) and bring it in the same horizontal plane with the bottom of the meniscus in the burette, as shown in Fig. 8.

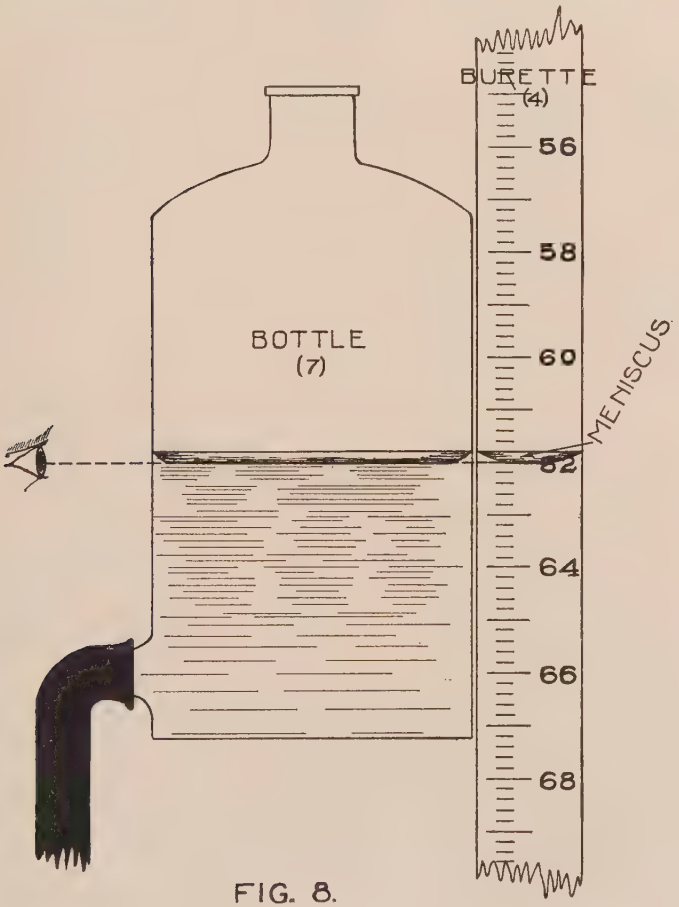


FIG. 8.

Analysis:

The quantities of reagents and wash water described in the foregoing method of analysis are intended mainly for the analysis of carburetted water gas, hence in the analysis of any other gas the quantities specified should be changed if it

is found to be necessary in order to insure complete absorption of the various constituents. This is also true of the oxygen and air required for explosion.

18. Introduce potassium hydrate solution slowly for first absorption as the tendency otherwise is to secure too high a percentage for the carbon dioxide.

19. Care should be taken in handling bromine. Keep it always under water, and do not allow it to come in contact with the skin. Bromine is an exceedingly energetic reagent and will cause painful chemical burns. If bromine fumes are breathed, relief from the irritation caused to the throat can be obtained by inhaling alcohol or steam. The slick feeling caused by getting potassium hydrate on the hands may be removed by a little dilute hydrochloric acid.

20. The absorption of illuminants by bromine is a heat producing reaction, and the increased temperature is apt to cause the sample to expand unduly and may cause the loss of a part of the sample by forcing it out through cock (1) and thus vitiate the analysis. If it is seen that the expansion is becoming excessive a little water may be added from (8). The bulb at the lower end of the burette is provided for this contingency, however. In the analysis of acetylene, which contains over 90 per cent. of illuminants, this is especially apt to occur. If the percentage of illuminants is high, it is well to admit a little water from (8) during the absorption with bromine to restore the normal temperature of the gas.

21. 20 cc. of potassium pyrogallate solution when mixed with 20 cc. of potassium hydrate solution produces a rise in the temperature of the mixture of about 5° F. over that of the original solutions. The heat gained by the gas in the burette due to this cause should be taken into consideration and sufficient time allowed the burette gases to resume initial temperature before reading. This solution should be passed into the burette very slowly, as the absorption of oxygen is rather sluggish. The absorption may be considered complete when

no further discoloration to purple or brown occurs upon introduction of the clear reagent.

22. The absorption of the last traces of CO is attended with difficulty, and hence the analyst should be careful to add sufficient copper monochloride solution and allow plenty of time for the complete absorption. The reagent being strongly acid, about 10 cc. of potassium hydrate solution should always be added, after passing in about 50 cc. of wash water to insure removal of all fumes of hydrochloric acid and followed with the customary wash water.

23. When carburetted water gas is being analyzed, double quantities of residual gases, oxygen and air may be taken for the explosion in order to secure higher accuracy.

24. Prior to all explosions sufficient time, at least two minutes, should be allowed for the gases to thoroughly diffuse through the oxygen and air added so as to give a homogeneous explosive mixture and insure the combustion of all the oxidizable gases.

25. No special care need be taken in measuring the amount of air, or of oxygen added for the explosion, though the amounts taken should not be less than those stated in the "Method." Care must be taken, however, to measure accurately the amount of gas taken for the explosion, and the total amount of the gas, air and oxygen just before the explosion.

26. Air is added to the mixture to be exploded merely to lessen the jar. If the gas is very poor, or contains large quantities of nitrogen no air need be added, and on the other hand if the gas is quite rich, no oxygen need be added air being sufficient, although if oxygen is available it is best added to insure combustion. An excess of Oxygen used with a very rich gas, such as Acetylene or a high candle-power Pintsch, Water or Coal Gas may result in the oxidization of some of the Nitrogen, but this is not very apt to occur. With extremely poor gas such as blast-furnace gas and the like, no explosion will take place even when oxygen is used and no air added. Oxyhydrogen gas may be necessary.

in such cases. This is made by the electrolysis of water slightly acidulated with sulphuric acid. Five to ten cc. of the oxygen and hydrogen mixture added in addition to the oxygen will always insure an explosion. As it recombines to water no especial reading or note of the volume added need be made.

27. Use only C. P. chemicals.

General Notes:

28. Never allow the funnel to become entirely empty; always keep about one-fourth inch of water or other liquid in the bottom to prevent the suction of air into the burette.

29. In acetylene, flue gas, engine exhaust, air and gasoline gas there is no hydrogen or methane, and hence the analysis need not be carried beyond the absorption with copper monochloride for CO, and the oxygen tank or apparatus, the electric coil, batteries, etc., need not be provided. In analyses of these gases the sum of the first four contractions subtracted from 100 gives the percentage of nitrogen.

30. Where many analyses are to be made, or where dispatch is an important element, it will be more satisfactory to obtain a cylinder of compressed oxygen for use in the hydrogen and methane determinations, but where the apparatus is to be moved from place to place, or is to be used only occasionally, or where the analyses are confined for the most part to gases which do not contain hydrogen or methane, such as flue gases, acetylene, air, engine exhaust, etc., a cheaper and quite satisfactory substitute can be had in a small retort by means of which oxygen can be generated on the spot as needed.

To generate oxygen this retort is filled not more than half full with a pulverized thoroughly mixed charge of potassium chlorate and manganese dioxide in the proportions of 20 of the first to one of the latter by weight. This is heated gently over a bunsen lamp. The evolution of oxygen begins at once and it may be led to the burette by means of a rubber tube. As 100 grams of potassium chlorate will produce 27,000 cc. of oxygen and only about 20 cc. of oxygen are

used for one analysis, a very small spoonful of the mixture will suffice for a great many explosions.

31. The method of analysis is so laid out that each determination must be made in its turn. With the exception of the absorption of CO_2 with KOH, and possibly that of CO with cuprous chloride, no isolated determination of any one constituent can be made with anything approaching accuracy without starting at the beginning and making all of the absorptions down to that constituent.

Careful readings of the burette should be taken before and after each determination, and especial care should be taken in making the analysis to thoroughly absorb each constituent in its turn. Partial absorption, or errors in the readings, will not only introduce an error in the percentages of the constituent in question, but the remaining portions of this constituent will affect the latter determinations in the analysis and thus have a doubly vitiating affect upon the accuracy.

Any CO_2 left after the first absorption will be absorbed by the KOH following the bromine and will be reported as illuminant or if by chance it is not absorbed by the KOH following the bromine, it will be absorbed by the alkaline pyrogallate solution used for oxygen absorption and will appear as O_2.

Any illuminant not absorbed will remain and burn to approximately 3½ times its volume of CO_2 when the explosion is made and will appear as CH_4. A very small proportion of illuminant left and burned and calculated to CH_4 will be sufficient to run the total of the analysis to more than 100 per cent. Any bromine vapors left after the absorption with bromine will be absorbed by the pyrogallate solution and will be reported as O_2.

Any unabsorbed CO will be burned to CO_2 in the explosion and will decrease the percentage of H_2 and CH_4, and increase the percentage of N_2 to the same extent.

Any unabsorbed O_2 left would decrease the percentage of H_2 and CH_4, and increase the percentage of N_2 to the same extent.

Any unabsorbed CO_2 after the explosion will decrease the percentage of CH_4 and increase that of the H_2 and N_2.

The N_2 being determined by difference will necessarily show the net effect of any and all errors in either readings of the burette, or in the performance of the analysis.

Interpretation.

To draw any trustworthy conclusions from a gas analysis, it is necessary to consider the analysis as a whole, rather than to base conclusions merely on the variation of the proportion of some one constituent from a standard figure that practice has taught to be normal.

For example, the candle-power of a coal gas or of a water gas may be said in a general way to vary with its percentage of illuminants, but it is not unusual to have a gas showing a high illuminant content, and at the same time a low candle-power on account of the percentage of carbon dioxide. oxygen or nitrogen, which neutralize the effect of the illuminants, and, conversely a low illuminant content may co-exist with a high candle-power if the percentage of the impurities is low.

The following statements in regard to inferences to be drawn from the excess or deficit of any one constituent in an otherwise normal analysis must be taken with the understanding that the analysis is otherwise normal, and, that the good or bad effect of the excess or the deficit of any one constituent, is not neutralized by the undue presence or absence of one or more of the other constituents.

The following figures are not given as absolute standards for all cases, but are averages, of those figures which under certain local conditions obtain in the best practice.

Conditions and requirements will vary the analysis in individual instances, and space is left in each line in which may be inserted as a standard for comparison, the average figures of a number of analyses taken at times when practice and experience prove conditions to be at their best.

The following gases are discussed.

Acetylene.
Air. (See paragraph under "Constituents.")
Blast-furnace gas.
Blue water gas.
Coal gas.
Electric furnace gas.
Engine exhaust. (See Waste Gas.)
Flue or chimney gas. (See Waste Gas.)
Gasoline gas.
Gas leaks.
Limekiln gas
Mine gas.
Natural gas.
Pintsch gas. (See Coal Gas.)
Producer gas.
Sewer gas.
Waste gases.
Water gas.

NOTE:—The term "Methane" as used in connection with such gases as carburetted water gas, coal, Pintsch, natural and gasoline gas include "ethane" and the other higher hydrocarbons of the methane series.

All figures given are for dry gases at 60° F. and 30" of Mercury.

The percentages are for volume—not weight—and, where the same applies, for combustion in air—not Oxygen—.

GAS LEAKS.

Analyses of air in connection with gas leaks to determine the nature of the gas and extent of the leaks where there is merely an odor are, almost without exception, futile. One per cent. of almost any gas mixed with air is sufficient to give a strong odor one-tenth of one per cent. being sufficient with some gas—while no accurate analysis can be made of an air mixture having less than 3 per cent. of the complicated mixture which we call an industrial gas.

Acetylene. (Commercial)	Per cent.
Carbon dioxide	....
Illuminants	96
Oxygen	0.75
Carbon monoxide	....
Hydrogen	....
Methane	....
Nitrogen	3.25
	100.00
B. t. u. per cu. ft.	1,400
Specific gravity	0.90

Acetylene should show 100 per cent. illuminants but it is almost impossible in ordinary work to get it entirely free from air. The variation of the illuminant content from 100 per cent. shows the extent of the air mixture, and this is checked if the oxygen and nitrogen found are in the 1 to 4 proportions of air.

If acetylene has been heated in generation, or in other ways, to a temperature in excess of 538° F. it will be broken up or polymerized into some higher hydrocarbons which are not soluble in bromine, and which will appear later as methane. Or, if the temperature has been quite high acetylene will break down completely into hydrogen and carbon. The presence of either methane or of hydrogen in any appreciable quantities in commercial acetylene is evidence of excessive temperature at some part of the process.

Blast-Furnace Gas.	Per cent.
Carbon dioxide	12.8
Illuminants	..
Oxygen	0.1
Carbon monoxide	26.5
Hydrogen	3.5
Methane	0.2
Nitrogen	56.9
	100.0
B. t. u. per cu. ft.	100
Specific gravity	1.01

In the above analysis the carbon dioxide comes from the complete combustion of the fuel or the secondary combustion of some of the carbon monoxide resulting from the reducing action in the cupola. As evidence of good fuel and heat economy the higher the carbon dioxide the better, but if the gas is to be subsequently used for burning or in gas engines its presence is a detriment. The reducing reaction of the carbon of the fuel on the iron oxide would produce carbon monoxide, which in the presence of air would burn to carbon dioxide.

Any oxygen occurring in blast-furnace gas would be the evidence of a leak.

Carbon monoxide would come from the reducing action in the furnace or from moisture in the fuel, in the charge, or in the blast, which would react with the hot carbon to form carbon monoxide and free hydrogen.

Hydrogen would be formed from moisture and its presence would be evidence of water or possibly of some volatile matter left in the coke, which latter would also be evidenced by the presence of methane. Methane would show that in addition to there being volatile or organic matter present, that the temperature was low.

Nitrogen is left from the air of the blast and while it is a detriment and to be kept as low as possible its presence in about the quantity shown is unavoidable.

BLUE GAS.

(Uncarburetted Water Gas)

	Per cent.
Carbon dioxide	3.0
Illuminants	....
Oxygen	....
Carbon monoxide	43.25
Hydrogen	50.00
Methane	0.50
Nitrogen	3.25
	100.00
B. t. u. per cu. ft.	308
Specific gravity	0.53

This gas is the result of the reaction described by the formula

$$C + H_2O = H_2 + CO$$

which takes place when steam is passed through hot carbon. If the reaction was perfect this gas would consist of practically 50 per cent. each of hydrogen and carbon monoxide, but there must be some air present and some carbon dioxide formed.

The carbon dioxide comes from air mixed and carbon monoxide burned to carbon dioxide or from the reaction itself. Its presence is evidence of an air leak or of too low a fire, too cold a fire, a shallow fire, or a fire with dead spots in it, or an excess of steam or steam which in some way has gotten through the fire and combined with the carbon monoxide to give carbon dioxide and hydrogen according to this formula:

$$CO + H_2O = CO_2 + H_2.$$

As in all industrial gases intended for burning the presence of CO_2 is a detriment, although its absence or very low percentage would be evidence of an underloaded condition of the machine and its elimination is not to be pursued too far.

Carbon monoxide comes from the reaction described, a deficit if accompanied by an excess of carbon dioxide is evidence of steam having passed through the fire.

An excess of hydrogen is evidence of some hydrocarbon in the fuel or of a steam leak through the fire. A deficit of hydrogen if accompanied by an excess of nitrogen is evidence of an air leak.

A small percentage of methane may come from volatile matter in the fuel along with insufficient heat to break this down into carbon and hydrogen.

Nitrogen comes from the air added, entrained or dissolved.

COAL GAS.

	Coal gas (16 c-p.) Per cent.	Pintsch gas Per cent.
Carbon dioxide	2.5	0.5
Illuminants	4.	23.5
Oxygen	0.5	0.5
Carbon monoxide	7.5	1.
Hydrogen	45.	18.5
Methane	35.	52.5
Nitrogen	5.5	3.5
	100.0	100.0
B. t. u. per cubic foot	616	1,200
Specific gravity	0.45	0.71

The carbon dioxide in coal gas or Pintsch gas comes either from an air leak in some hot part of the process through which air is drawn, the oxygen of which burning to carbon dioxide, or more likely a leak in a retort or connection through which stack gases from the bench fire is drawn. Carbon dioxide constituent should be kept as low as possible.

The illuminants come from the distillation of the coal or of the oil and to this constituent is due a large part of the calorific and practically all of the illuminating value. An excess of it would mean—especially along with a deficit of methane—too low heats or too short a time of carbonization. An excess would show a good gas but would evidence an underloaded, or underheated condition and an uneconomical operation. A deficit of illuminants if accompanied with excess methane would show too high heats, or if with an excess of hydrogen very excessive heats.

An excess of oxygen would mean an air leak at some part of the process after the gas was cooled below the ignition point. It might mean a leaky exhauster connection or too much air for purification. A small percentage of free oxygen should be present as evidence of sufficient air for purification, but aside from this the lower the oxygen content the better,

especially as oxygen almost invariably comes from the air and carries with it four times its volume of inert nitrogen. A deficit or total absence of any free oxygen means insufficient air for purification.

Carbon monoxide comes from the partial combustion of carbon with oxygen mixed or entrained with the coal or oil, or from water or moisture which breaks up and forms carbon monoxide and hydrogen. An excess would mean an air leak in some hot part of the process, or more likely water or moisture. As water would form this blue gas at the expense of the best part of the illuminants, the presence of an excess of carbon monoxide, especially if accompanied with high hydrogen, may be regarded as an indication of uneconomical conditions. A deficit of carbon monoxide would mean too low heats.

Hydrogen in coal gas or pintsch gas may come from either the breaking up of water by hot carbon, or from the breaking down of hydrocarbons by heat. An excess of hydrogen if accompanied by an excess of carbon monoxide would mean wet coal or water mixed with the oil, if not so accompanied would mean too long carbonization, insufficient charge or excess heats, as any hydrocarbon will break down into hydrogen and lampblack if heated sufficiently high. A deficit of hydrogen would mean low heats or an underloaded condition of the retorts.

Methane comes from the hydrocarbons which have been subjected to temperatures too high to result in the formation of illuminants and not high enough to produce free hydrogen. An excess would mean too high heat or too long carbonization, especially if accompanied with high hydrogen.

Nitrogen comes from the air for the most part and its presence is evidence of a leak or of same other condition which should not exist. A certain percentage is unavoidable, especially as some air must be added to the gas for purposes of purification, but the proportion should be kept as low as practicable. An excess of Nitrogen would mean an air leak; if accompanied with high carbon dioxide or low hydrogen it would mean air

or products of combustion mixed while the gas was hot, if accompanied by high oxygen it would mean air mixed after gas was cold.

ELECTRIC FURNACE GAS.

	Per cent.
Carbon dioxide	0.5
Illuminants	..
Oxygen	0.5
Carbon monoxide	59.5
Hydrogen	24.5
Methane	1.5
Nitrogen	13.5
	100.0
B. t. u. per cubic foot	287.0
Specific gravity	0.75

The above is an analysis of the gases given off in an electric furnace where the heat is supplied by electricity instead of by combustion of the fuel, and carbon is used as the reducing agent for some refractory oxide. If the mixture were pure and there was no air present the analysis would show 100 per cent. carbon monoxide.

The carbon dioxide present comes from the burning of the gas with air mixed after the gas has been cooled or was away from the presence of hot carbon. The oxygen comes from air leakage.

The carbon monoxide is the result of the reducing reaction of the process, or of oxygen from the air, or in the mixture combined with the carbon, or from water or moisture broken up by the hot carbon to form carbon monoxide and hydrogen.

The hydrogen is from water or moisture as above or from the breaking down of some hydrocarbon in the mixture.

The methane is from the partial breaking down of some hydrocarbon.

The nitrogen is from air leaked in or entrained with the mixture.

Gasoline Gas.
("Greased Air.")

	For Burning Per cent.	From Engine carburetter (explosive mixture) Per cent.
Carbon dioxide	..	..
Illuminants	1.5	0.6
Oxygen	18.5	17.7
Carbon monoxide	..	..
Hydrogen	..	..
Hexane C_6H_{14}	10.3	2.9
Nitrogen	69.7	78.8
	100.0	100.0
B.t.u. per cubic ft.	514	145
Specific gravity	1.22	1.02

Gasoline gas or carburetted air consists of air more or less saturated with gasoline vapors. These vapors consist of a mixture of ethylene C_2H_4 and hexane—one of the methane group— C_6H_{14}. The direct determination of the hexane is rather complicated and as the oxygen and nitrogen are always in the proportion of air, a very accurate analysis can be arrived at by determining the hexane by difference.

The analysis is performed by determining the illuminants and oxygen in the regular way. Now as the nitrogen content comes from this air and being unchanged is equal to 3.77 times the oxygen content its proportion can be calculated. The difference between the sum of all the other constituents and 100 would be the percentage of hexane.

An excess of either illuminants or hexane which come from the gasoline would mean an excess of gasoline or a deficit of air used, which would result in a smokey flame, blackened mantle, or condensation and deposit of this hydrocarbon in the pipes. If sample is taken from the carburetter of an engine, an excess would result in smoke or soot in the ex-

haust, carbon deposit in the cylinder and on the plugs, misfiring and lowering of capacity.

A deficit of either of these would mean a low candle-power due to too little gasoline, too much air or not the right "number" or adjustment on the gas machine, or an overload on the system. In an engine mixture a deficit would result in back-firing, pre-ignition, and explosion in muffler or exhaust system and loss of power.

LIME KILN GAS.

	Per cent.
Carbon dioxide	35.0
Illuminants	..
Oxygen	2.0
Carbon monoxide	0.5
Hydrogen	..
Methane	..
Nitrogen	62.5
	100.0
B. t. u. per cubic ft.	..
Specific gravity	1.17

The carbon dioxide in this gas comes from both the combustion of the fuel and from the reduction of the limestone—calcium carbonate—which is being burned to lime—calcium oxide. The higher percentage of carbon dioxide the better, a deficit would show an underloaded condition, or insufficient fuel and heat.

The oxygen would come from the air through the fire, and as in other waste gases a small excess is essential to insure complete burning of the fuel. The free oxygen, however, should be kept as low as possible not to produce carbon monoxide which would be evidence of incomplete burning.

Carbon monoxide comes from partially burned fuel and is evidence of poor fuel economy.

The nitrogen is left after the oxygen of the air is burned out. (See "Waste Gases.")

MINE GAS.

	Per cent.
Carbon dioxide	3.0
Illuminants	..
Oxygen	6.5
Carbon monoxide	1.0
Hydrogen	5.5
Methane	59.5
Nitrogen	24.5
	100.0
B. t. u. per cubic ft.	622
Specific gravity	0.70

The above is an analysis of a sample taken from a closed passage in a coal mine. It shows natural gas with about 30 per cent. air mixture. Such a mixture would be asphyxiative and if mixed with more air would become explosive. It shows an almost complete absence of ventilation. (See Natural gas.)

NATURAL GAS.

	Per cent.
Carbon dioxide	2.0
Illuminants	0.4
Oxygen	0.4
Carbon monoxide	0.5
Hydrogen	1.6
Methane	93.5
Nitrogen	1.4
	100.0
B. t. u. per cubic ft.	960
Specific gravity	0.58

Natural gas comes from great depths in the ground and its composition and proportions vary very widely with different wells and localities, and the proportions are not controllable except possibly for oxygen and nitrogen drawn in as air where the wells are pumped and are under suction. Carbon dioxide often occurs along with the gas.

Illuminants as oil vapors are found, especially where the wells are nearing exhaustion and in such cases sulphuretted hydrogen and carbon dioxide are apt to appear or the proportion to increase.

Methane is the active principle in natural gas and the other constituents may be regarded as impurities or diluents. The higher the percentage of methane the more valuable is the natural gas.

PRODUCER GAS.

	Per cent.
Carbon dioxide	6.0
Illuminants	..
Oxygen	..
Carbon monoxide	22.0
Hydrogen	11.0
Methane	3.0
Nitrogen	50.0
	100.0
B. t. u. per cubic ft.	138
Specific gravity	0.89

Carbon dioxide is to be avoided in producer gas. Its presence is evidence of too low a fire, of a cold fire or one with dead spots in it, of an overloaded machine or of an excess of air. An absence or a great deficit of carbon dioxide would show that the machine was underloaded and not operating up to its capacity.

Carbon monoxide and hydrogen are produced when the conditions are best and the opposite of those conditions which produce carbon dioxide result in a high carbon monoxide and hydrogen content and evidence good practice. Low hydrogen with high nitrogen show an excess or leak of air, as the hydrogen in the gas combines with the oxygen in the air and disappear as water vapor leaving the nitrogen. Methane is produced when the heats are low or the machine is underloaded, and, while it adds greatly to the value of the gas, its presence may be taken as evidence that the full capacity

is not being gotten from the producer and that either there is not sufficient steam and air, or the fire is too cold or too shallow. Between 50 per cent. and 60 per cent. of nitrogen is unavoidable in producer practice, although as in every industrial gas the presence of nitrogen is a detriment. An excess of nitrogen especially if accompanied by an excess of carbon dioxide or carbon monoxide, or a deficit of hydrogen is evidence of an excess of air.

SEWER GAS.

	Per cent.
Carbon dioxide	3.10
Illuminants	..
Oxygen	12.01
Carbon monoxide	1.80
Hydrogen	..
Methane	1.70
Nitrogen	78.22
Sulphuretted hydrogen	3.17
	100.00
B. t. u. per cubic ft.	144
Specific gravity	1.002

The poisonous effects of air or gas from sewers, cesspools and the like are due to the sulphides of ammonium or of hydrogen although asphyxiation may occur solely from the want of oxygen.

Sewer gas usually contains methane and carbon monoxide produced by decay to which along with hydrogen sulphide any combustion or explosion of this gas is due.

The proportion of the different constituents of sewer gas vary over very wide ranges according to the amount of ventilation.

A fair average analysis, however, would be about as stated above. The most satisfactory means of identifying sewer gas is by a qualitative test for sulphuretted hydrogen made in the well known way with test paper wet with a solution of acetate of lead.

Waste Gas.

	Flue or chimney gas (soft coal) Per cent.	Gas engine exhaust (25 c-p. water gas) Per cent.
Carbon dioxide	13.5	8.9
Illuminants	....	...
Oxygen	5.5	7.7
Carbon monoxide	....	....
Hydrogen	....	....
Methane	....	....
Nitrogen	81.0	83.4
	100.0	100.0
B. t. u. per cu. ft.	....	....
Specific gravity	1.05	1.04

The higher the percentage of carbon dioxide in flue gas or engine exhaust, the more perfect the combustion and the better the conditions.

Air contains practically 21 per cent. by volume of oxygen. When oxygen combines with carbon to form carbon dioxide, it produces its own volume of carbon dioxide, hence if carbon is burned to carbon dioxide with oxygen from the air the sum of the uncombined oxygen and the carbon dioxide produced must equal 21 per cent. of the volume of the products of combustion.

When oxygen combines with carbon to form carbon monoxide, it produces twice its volume of this gas, hence if carbon was partially burned in air and produced both carbon dioxide and carbon monoxide, then the formula, $CO_2 + \frac{1}{2} CO + O = 21$ per cent., would be correct and might be used as a check on the accuracy of an analysis where coke or hard coal is used as a fuel.

The use of such a formula, however, as a check on any waste gas analysis where the fuel contained any proportion of hydrogen—either free or combined—would not answer, as the hydrogen in the fuel combines with the oxygen to form water vapor, and, as this moisture would not appear in the analysis, some of the oxygen will not be accounted for, and the percentage of nitrogen which would go to make up

the 100 per cent. would seem unduly high and appear to indicate poor economy when such might really not be the case. Just the proper amount of hydrogen burned in air would form water with all of the oxygen and give a waste gas analysis showing 100 per cent. free nitrogen.

Incidentally, this fact destroys the accuracy and value of the tables and curves made by those selling continuous flue gas analyzing apparatus, in which the claim is made that the deficit of carbon dioxide below 21 per cent. shows exactly the extent of the imperfect combustion in the boiler.

A deficit of carbon dioxide with a corresponding increase in nitrogen, if accompanied by a large excess of oxygen, would mean an excess of air either added or drawn in through leaks, while if unaccompanied by such excess of oxygen would merely show a fuel high in hydrogen.

It is impossible to get perfect conditions in commercial boiler or engine practice, and an excess of air shown by a small percentage of free oxygen is essential to ensure complete combustion and is of much less detriment than a deficit of air, which would result in an imperfect combustion of a part of the fuel.

As the combustion in an engine cylinder is much more rapid and violent than is the combustion in a boiler furnace, a slightly larger excess of free oxygen is advisable in engine than in boiler practice.

A large excess of oxygen is evidence of too much air in the mixture, or of an over-blown fire. The oxygen should be kept as low as possible without producing carbon monoxide. The analyst must be quite sure, however, that the free oxygen showing in the analysis really came through the engine cylinder, or the fire, and did not leak into the flue or the setting, or especially into the sample can after the fire was passed. The importance of this precaution can scarcely be over estimated.

The presence of any carbon monoxide is evidence of insufficient air, incomplete combustion and of inefficient opera-

tion. If the conditions of air supply are much worse, methane or even illuminants may appear.

Less than from 3 per cent. to 8 per cent. of free oxygen in waste gas is bad, the presence of carbon monoxide is worse, while any methane or illuminants at all is simply awful.

When soft coal, oil, gas, or in fact any fuel excepting pure carbon, is burned with air, the hydrogen combines with a portion of the oxygen and does not appear in the analysis at all, its place being taken by nitrogen. The excess of nitrogen in a waste gas over the 79 per cent. which air contains is roughly in proportion to the amount of hydrogen, either free or combined, with the fuel contained. This applies to all hydrocarbons, and also though in much less degree, to the carbohydrates, such as wood, etc., which, while they do contain hydrogen, also contain oxygen in the proportion of water.

The most reliable rule for waste gas is to see that there is always sufficient free oxygen to insure complete combustion and not such an excess as to evidence over-blowing or over-dilution. The percentage of free oxygen and absence of carbon monoxide is a more reliable guide in boiler or engine practice than the carbon dioxide content.

WATER GAS.

(Carburetted, 24 C. P.)	Per cent.
Carbon dioxide	3.0
Illuminants	12.0
Oxygen	0.5
Carbon monoxide	29.0
Hydrogen	33.0
Methane	18.0
Nitrogen	4.5
	100.0
B. t. u. per cu. ft.	672
Specific gravity	0.68

There are a number of chemical reactions taking place in a water gas set, some beneficial, some the reverse, and it is only by keeping these properly balanced that the best results can be obtained.

First the water in the form of steam is broken up by the hot carbon into monoxide and hydrogen, forming what is commonly called "Blue Gas" If steam passes through the fire and is mixed with this blue gas a further reaction between the steam and some of the carbon monoxide takes place forming carbon dioxide and hydrogen.

If air is mixed with the hot blue gas, either a part of the hydrogen combines with the oxygen and disappears as water vapor or a part of the monoxide combines with the oxygen forming dioxide. In either event leaving the nitrogen of the air.

In the carburetter the changes in the oil depend very largely upon the temperature. If there is not sufficient heat the oil is in a large measure merely volatilized to recondense upon becoming cold instead of being dissociated or cracked into a permanent gas. When the temperature is at the most economical point the oil is broken up into what we call illuminants and what we call methane and a small volume of hydrogen. As the temperature gets too high the illuminants are broken up into methane, carbon and hydrogen. With excessive temperatures the methane and all of the proportions added as oil will break down into their elements of carbon in the shape of lampblack and free hydrogen.

The extent and the mutual balance of these reactions can be told by a study of the analysis.

An excess of carbon dioxide or "Acid" would show an excess of steam or poor fuel, or an overloaded machine, a low fire, a cold fire, a shallow fire, an uneven fire or a fire with dead spots in it. An excess may be due also to a steam leak in the "up and down" valve or incomplete purging of the machine after the blast.

A deficit or absence of carbon dioxide while being an advantage in the finished gas is evidence of too little steam for the temperature and the amount of fire, and shows an uneconomical condition of operation on account of the machines being underloaded, and not giving their output. A small fire and too little blue gas along with excessive heat in the

checkerwork will result in a gas showing very little if any dioxide, the dioxide produced in the generator being reduced to monoxide with the oil as fuel which is not at all economical. Very low dioxide is evidence of conditions which produce naphthalene, and, while dioxide is an impurity and to be kept low, it will not do to crowd it too far toward extinction.

An excess of illuminants show too little blue gas or too much oil, cold checkerwork or a poor fire and show a gas which while possessing a high candle-power and calorific value of the station will not stand transmission.

A deficit of illuminants shows an excess of blue gas or too little oil, or, if accompanied with excess hydrogen, shows too much heat in the checkerwork.

Excess oxygen shows air added by leak or otherwise after the gas is cold. It may show also an excess of air for purification, insufficient purging after blast, a leaky exhauster or connection, too little water in seal pot, leaks in valves of secondary air system and, especially, it may mean carelessness in getting the sample.

An absence of oxygen would mean insufficient air for purification other than its room is much better than its company.

An excess of carbon monoxide would mean a good fire. When accompanied with excess hydrogen, it means steam mixed with the oil gas.

A deficit of monoxide when accompanied with excess dioxide and, especially, an excess of nitrogen shows an air leak while the gas is still hot.

An excess of hydrogen would show overheated checkerwork and breaking up of oil, especially when lampblack appears on the water of the seal pot.

A deficit of hydrogen shows insufficient steam, or too little fire, or, if accompanied with excess nitrogen, it shows an air leak while the gas is hot.

An excess of methane would mean a low or dirty fire, too little steam, dirty checkerwork or overload, or a cold machine.

A deficit shows excess temperature which breaks up the oil, especially when accompanied with excess hydrogen.

An excess of nitrogen would show air added or mixed or leaked, also insufficient purging, leaky air valves or excess air for purification.

Deficit of nitrogen—there is no such thing as too little of this inert constituent.

The Determination of the Specific Gravity of Gas by the Orifice Method.

The determination of the specific gravity of a gas by the "orifice" or "effusion" method is based upon the principle, that equal volumes of gases under equal pressures will effuse or flow through small circular orifices at rates such that the squares of the times required are proportional to the respective densities of the gases. Thus the square of the time required for a given volume of gas under any pressure to flow through a given orifice is to the square of the time required for the same volume of air under the same pressure to pass through the same orifice, as the density of the gas is to the density of the air, or since the density of air is usually taken as the the standard of 1, the square of the time for gas divided by the square of the time for air equals the specific gravity of the gas.

The specific gravity attachment for the burette shown in Fig. 4, consists of a small hollow metal nozzle into which is cemented a glass tube, and into the end of this glass tube is fused a thin platinum plate perforated at its center by a circular orifice of about 1/250 of inch in diameter. For protective purposes when the attachment is not in use a removable metal cap is screwed onto the lower brass piece.

The specific gravity attachment is used as follows:

First fill leveling bottle (7) Fig. 5 and burette (4) with about 500 cc. of water well saturated at the temperature of the room with the gas of which the specific gravity is to be determined. Then after removing cup (5), opening cock (1) and adjusting cock (2) to fully connect bottle (7) with burette (4), slowly raise bottle (4) until the burette is filled

to the ground joint at the extreme top. The burette is then ready for the test. Now attach the hose leading from the sampling can or gas pipe and slowly lower bottle (7) keeping the level of water in same slightly higher than the water level in the burette and thus avoid any possible inward leaks of air. Draw in gas sample until the water level in burette is at least as low as point (19), then close cock (1) and place bottle (7) on shelf (21). Immediately attach the specific gravity device to the top ground joint of burette by means of a piece of heavy walled rubber tubing about 1½ inches long and of a bore to fit snugly for at least ½ inch over both the metal tube and the ground joint of the burette.

If the gas is not at the temperature of the burette, allow ample time for it to acquire the temperature of the jacket water (11).

Open fully cock (1) to connect burette with attachment only. Place eye on a level with the 100 cc. burette graduation and start stop watch the instant that the bottom of the meniscus of the water level in the burette passes the 100 cc. mark. Allow gas to flow naturally outward through orifice until the bottom of the meniscus of the water level passes the 10 cc. mark in the burette at which time the stop watch is stopped and cock (1) immediately closed to further outward flow of gas. Note carefully the elapsed time in seconds and fractions thereof required to pass the 90 cc. of gas. Repeat until at least three consistent runs have been made.

After the last gas run remove the specific gravity attachment, open cock (1) and purge out gas by bringing water level just to top of ground joint. Then lower bottle (7) until a few cc. of air have entered the burette. Now close cock (1) and adjust cock (2) to connect burette (4) with seal bottle (10). Place cup (5) on ground joint and fill with well aerated distilled water, open cock (1) and allow water from cup (5) to flow into burette. Pass in this way at least two cupsful of water, care being taken not to allow any more air to enter. After the gas saturated water is thus removed from the burette, adjust cock (2) to connect bottle

(7) and burette (4) and then open cock (1) until the water level just reaches the end of the second joint.

Now, lower bottle (7) and draw in air to point (19), close cock (1), place bottle (7) on shelf (21) and allow air to stand a few minutes to complete saturation by water vapor and to attain the temperature of the water-jacket (11), after which follow out the same procedure as just described for the gas.

After the respective times in seconds have been noted the specific gravity may be calculated as shown in the following examples:

Time in seconds required for	Time of flow — Gas	Time of flow — Air
	120.2	152.4
90 cc.	120.0	152.6
	120.2	152.2
Average	120.1	152.4

120.1 squared or 120.1 × 120.1 = 14,424.01

152.4 squared or 152.4 × 152.4 = 23,225.76

$$\frac{14,424.01}{23,225.76} = 0.621.$$

Notes:

(1) Before making determinations always remove the protective metal cap.

(2) Avoid placing finger on end of glass tube where platinum is situated as the orifice is readily stopped or damaged by contact. The orifice should be kept clean to give good results.

(3) Always place leveling bottle (7) at the same height when making a determination and see that the quantity of water contained in leveling bottle (7) hose (14) and burette (4) is the same throughout the tests with both gas and air. The foregoing precautions are essential as any deviation from the height at which bottle (7) is placed, or quantity of water used in each run, changes the pressure forcing the gas or air through the orifice and hence give erroneous results.

(4) See that both cocks (1) and (2) are free from foreign matter in the holes drilled in them and are always open full

wide when they are opened at all so as to give water free and unobstructed passage.

(5) Always keep interior of attachment as dry as possible and free from dust.

(6) Always attach specific gravity device by heavy walled pure gum tubing of appropriate bore so as to make a snug fit and thus avoid errors due to leakage.

Calculation of Calorific Value, Specific Gravity or Density of a Gas from its Analysis.

For all practicable purposes, non-combustible impurities in a gas lower the calorific value of that gas in direct proportion to their presence. That is to say, 50 per cent. of, say, carbon dioxide in a combustible gas will deduct 50 per cent of the B. t. u. of the pure gas, or in other words 100 ft. of a 50 per cent. mixture of gas and air would have the same heating value as 50 ft. of the same gas 100 per cent. pure.

Each of the combustible constituents also effect the calorific value in direct proportion to its presence and contributes its own proportion of the total calorific value just as if that constituent was burned independently. Knowing the analysis of a gas and the calorific value per cubic foot of the constituents, the calorific value of the whole may be calculated by multiplying the percentage as shown by the analysis by the constant corresponding to each constituent. The sum of these would be the total B. t. u. for the gas.

All of the heating value of an industrial gas is contributed by four of its seven constituents, namely: Illuminants, carbon monoxide, hydrogen and methane, while three, carbon dioxide, oxygen and nitrogen are impurities and detract from the value.

By determining the heating value of chemically pure carbon monoxide, hydrogen and methane in a Junker's calorimeter, constants for these constituents can be arrived at with great accuracy, but unfortunately such is not the case with the illuminants as this constituent consists of a number of more or less complicated hydrocarbons, which vary in different gases and under different conditions in the same gas. Hence no one definite constant can be stated which will apply

in all cases, but a number of different figures for the different gases must be used. A constant for the Illuminants in any particular gas can be readily calculated and established from the known B. t. u. and analysis of the gas. A considerable number of analyses should be taken and after deducting from the total B. t. u. as given by the calorimeter the proportion due to the Carbon Monoxide the Hydrogen and the Methane according to their well authenticated values the constant for the Illuminants would be the product of the number of remaining B. t. u. divided by the percentages of Illuminants from the analysis.

The constants below for the calorific value and for the density of the respective constituents are the averages of a very large number of tests made on the respective gases, and by their use the calorific value or the specific gravity—to within less than 2 per cent. either way from the results given by a calorimeter or by an orifice—can be calculated from a carefully made analysis.

Constituent	Constant or gross B. t. u.	Specific gravity density air = 1
Carbon dioxide	.0000	1.52
Illuminants in:		
Pintsch gas	.2580	1.61
28 C. P. water gas	.2550	1.59
24 C. P. water gas	.2412	1.51
Oil gas	.2405	1.50
20 C. P. mixed gas	.2370	1.48
16 C. P. coal gas	.2308	1.44
Natural gas	.1586	0.98
Gasoline gas	.1586	0.98
Acetylene	.1475	0.90
Oxygen	.0000	1.1
Carbon monoxide	323	0.97
Hydrogen	326	0.069
Methane	.1009	0.55
Ethane	.1762	1.04
Hexane	.4760	2.97
Nitrogen	.0000	0.97

For example of a calculation for heating value take the 16 C. P. coal gas analysis given on page 50 the calculation would be as follows:

Constituent	Percentage by volume		Constant or B. t. u. per cu. ft.		
Carbon dioxide	2.5	multiplied by	000	equals	0000
Illuminants	4.0	"	2308	"	9232
Oxygen	0.5	"	000	"	0000
Carbon monoxide	7.5	"	323	"	2422
Hydrogen	45.0	"	326	"	14670
Methane	35.0	"	1009	"	35315
Nitrogen	5.5	"	000	"	0000
Total	100.0	B. t. u. per 100 cu. ft.			61639
		B. t. u. per cu. ft.			616.4

As the specific gravity of a gas is the specific gravity of its respective parts, its density may be readily calculated from its analysis of the specific gravity of its analysis if the specific gravity of its constituents are known.

The densities are given in the table above and the calculation of the density of the 24 C. P. water gas given on page 321 is added as an example.

Constituent	Percentage by volume		Density or specific gravity		
Carbon dioxide	3.0	×	1.52	=	4.56
Illuminants	12.0	×	1.51	=	18.12
Oxygen	0.5	×	1.1	=	0.55
Carbon monoxide	29.0	×	0.97	=	28.13
Hydrogen	33.0	×	0.069	=	2.28
Methane	18.0	×	0.55	=	9.90
Nitrogen	4.5	×	0.97	=	4.36
	100				
Sp. gr. per 100 cu. ft.					67.90
Sp. gr. per ft.					0.68

The following forms for a laboratory log sheet and for a laboratory report will be found convenient.

LABORATORY LOG SHEET. DATE 191-

GAS ANALYSES AND CALCULATIONS.

Time					
C. C. & kind of gas					
Constituent	Burette reading in C. C.	Per cent. by Volume	Calculated heat value in B. t. u. per cu. ft.		Calculated Specific Gravity
Carbon dioxide	After absorption by KOH		000.00	000.00	
Illuminants	After absorption by Br.				
Oxygen	After absorption by Pyro		000.00	000.00	
Carbon monoxide	After absorption by Cu_2Cl_2				
Hydrogen	Gas for explosion				
Methane	Mixture before explosion				
Nitrogen	After explosion		000.00	000.00	
	After absorption by KOH				

SPECIFIC GRAVITY TESTS.

Time				
C. C. and kind of gas				
Test number	Time of gas flow in seconds	Time of air flow in seconds	Time of gas flow in seconds	Time of air flow in seconds
1				
2				
3				
Average				
Average squared				
Spec. gr'v'ty by calcula'n				

DAILY REPORT OF _____ STATION.

LABORATORY.

Day beginning 7 A. M. _____ 191

GAS ANALYSIS.

Time / Kind of Gas / Constituent			Average
	Per cent. by volume	Per cent by volume	Per cent. by volume
Carbon dioxide			
Illuminants			
Oxygen			
Carbon monoxide			
Hydrogen			
Methane			
Nitrogen			
Total			

SPECIFIC GRAVITY TEST.

Time / Kind of gas			Average
Specific gravity by Orifice method			
Specific gravity by calculation			

HEATING VALUE TESTS.

Time / Kind of gas					Average
Heating value in B. t. u. per cu. ft.	B. t. u. per cu. ft.	B. t. u. per cu. ft.	B. t. u. per cu. ft.	B. t. u. per cu. ft.	B. t. u. per cu. ft.
Gross B. t. u. by calorimeter					
Gross B. t. u. by calculation					

APPENDIX A.

BIBLIOGRAPHY.

The following works treat with more or less fullness the subject of gas analysis.

Reduction of Factors for Gases,	H. B. MacFarland.
Gas and Fuel Analysis,	A. H. Gill.
Method of Gas Analysis,	W. Hempel.
Technical Gas Analysis,	F. H. Bates.
Technico-Chemical Analysis,	Dr. G. Lunge.
Gas Analyst's Manual,	Jaques Abady.
Chemistry of Gas Manufacture, I, Manf.,	W. J. Butterfield.
Calorimetry of Gas,	F. H. Bates.
Chemical Arithmetic,	Horace L. Wells.
Chemistry of Coke,	W. G. Anderson.
High Temperature Measurements,	Le Charelier.
Volumetric Analysis (including gas),	F. Sutton.
Oil Analysis,	A. H. Gill.
The Analysis of Industrial Gases,	J. M. Morehead.
Practical Testing of Gas,	C. H. Stone.
Engineering Chemistry,	Thos. B. Stillman.
Thermo Chemistry,	Julius Thomsen.
The Gas Engine,	Fred R. Hutton.
The Chemistry of Gas Manufacture,	H. M. Royle.
The Calorific Power of Fuels,	H. Poole.
A Dictionary of Chemical Solubilities,	A. M. Comey.
Chemical Arithmetic,	W. Dittmar.
Physico-Chemical Tables,	John Castell-Evans
The Chemistry of Illuminating Gas,	N. H. Humphreys.
American Producer Gas Practice,	Nesbit Latta.
Gas Engineer's Laboratory Handbook,	Hornby.
Gas Analysis (Western Gas Ass'n, 1893),	O. O. Thwing.

APPENDIX B.

Some Diverse Characteristics of Ordinary Gases.

There is 50 per cent. more difference between the weight of carbon dioxide and hydrogen than there is between the weight of water and mercury, or of lead and white pine.

Nitrogen is an inert, passive, dead substance. Fluorine is one of the most energetic substances in nature.

Hydrogen, nitrogen and chlorine are chemical elements. Acetylene, hydrogen-chloride and methane are combinations of two or more elements.

Oxygen is the supporter of both animal and vegetable life, cyanogen is the most actively poisonous substance known to science, or to medicine.

Fire or burning is a combination of fuel with oxygen, carbon dioxide is used as a fire extinguisher.

A gas explosion is a combination or association of oxygen with the fuel. A gunpowder or a dynamite explosion is a dissociation of the nitrogen from the other elements in the explosive.

Hydrogen chloride is an exceedingly strong acid, ammonia is an almost equally strong alkali, methane is neutral.

Carbon dioxide has a negative heat value of 14,500 B. t. u. for each pound of contained carbon. That is, it has 14,500 B. t. u. less than none at all. Hydrogen has a heat value of 62,100 B. t. u. per pound, being greater than that of any other known substance.

Carbon dioxide is so heavy that it can be left for a time in an open bucket, or beaker, or can be syphoned or poured like water from one vessel into another. Hydrogen is the lightest of all substances—is used for balloons—and at the same time in chemical action is just as distinctly a metal as is zinc, copper, iron or silver.

Carbon dioxide will smother a fire. Nitrogen will not burn. Hydrogen burns with a colorless flame and acetylene possesses 240 candle-power.

Oxygen is the most abundant substance in the universe. Argon is so rare as to leave doubts as to its existence.

Methane is practically insoluble in water. Ammonia is absorbed to the extent of 1,000 times the volume of water.

Chlorine may be liquefied and solidified with very meager pressures, and with temperatures well within atmospheric limits. Hydrogen and methane have never been even liquefied, without the most extreme conditions of pressure and refrigeration.

Air, hydrogen and methane are odorless, colorless, and tasteless and can be swallowed or inhaled with impunity. Chlorine has a strong, pungent, unbreathable odor, is greenish in color, and not only can not be breathed or swallowed, but it produces severe chemical burns if brought in contact with the skin.

APPENDIX C.

Constants for Calculation of Specific Gravity by Orifice Method.

Time of flow Min.	Sec.	Constant	Time of flow Min.	Sec.	Constant	Time of flow Min.	Sec.	Constant
	10	100		47	2,209	1	23	6,889
	11	121		48	2,304	1	24	7,056
	12	144		49	2,401	1	25	7,225
	13	169				1	26	7,396
	14	196		50	2,500	1	27	7,569
	15	225		51	2,601	1	28	7,744
	16	256		52	2,704	1	29	7,921
	17	289		53	2,809			
	18	324		54	2,916	1	30	8,100
	19	361		55	3,025	1	31	8,281
				56	3,136	1	32	8,464
	20	400		57	3,249	1	33	8,649
	21	441		58	3,364	1	34	8,836
	22	484		59	3,481	1	35	9,025
	23	529				1	36	9,216
	24	576	1	0	3,600	1	37	9,409
	25	625	1	1	3,721	1	38	9,604
	26	676	1	2	3,844	1	39	9,801
	27	729	1	3	3,969			
	28	784	1	4	4,096	1	40	10,000
	29	841	1	5	4,225	1	41	10,201
			1	6	4,356	1	42	10,404
	30	900	1	7	4,489	1	43	10,609
	31	961	1	8	4,624	1	44	10,816
	32	1,024	1	9	4,761	1	45	11,025
	33	1,089				1	46	11,236
	34	1,156	1	10	4,900	1	47	11,449
	35	1,225	1	11	5,041	1	48	11,664
	36	1,296	1	12	5,184	1	49	11,881
	37	1,369	1	13	5,329			
	38	1,444	1	14	5,476	1	50	12,100
	39	1,521	1	15	5,625	1	51	12,321
			1	16	5,776	1	52	12,544
	40	1,600	1	17	5,929	1	53	12,769
	41	1,681	1	18	6,084	1	54	12,996
	42	1,764	1	19	6,241	1	55	13,225
	43	1,849				1	56	13,456
	44	1,936	1	20	6,400	1	57	13,689
	45	2,025	1	21	6,561	1	58	13,924
	46	2,116	1	22	6,722	1	59	14,161

APPENDIX C.—(Continued.)

Time of flow Min.	Sec.	Constant	Time of flow Min.	Sec.	Constant	Time of flow Min.	Sec.	Constant
2	0	14,400	2	40	25,600	3	20	40,000
2	1	14,641	2	41	25,921	3	21	40,401
2	2	14,884	2	42	26,244	3	22	40,804
2	3	15,129	2	43	26,569	3	23	41,209
2	4	15,376	2	44	26,896	3	24	41,616
2	5	15,625	2	45	27,225	3	25	42,025
2	6	15,876	2	46	27,556	3	26	42,436
2	7	16,129	2	47	27,889	3	27	42,849
2	8	16,384	2	48	28,224	3	28	43,264
2	9	16,741	2	49	28,561	3	29	43,681
2	10	16,900	2	50	28,900	3	30	44,100
2	11	17,161	2	51	29,241	3	31	44,521
2	12	17,424	2	52	29,584	3	32	34,944
2	13	17,689	2	53	29,929	3	33	45,369
2	14	17,956	2	54	30,276	3	34	45,796
2	15	18,225	2	55	30,625	3	35	46,225
2	16	18,496	2	56	30,976	3	36	46,656
3	17	18,769	2	57	31,329	3	37	47,089
2	18	19,044	2	58	31,684	3	38	47,524
2	19	19,321	2	59	32,041	3	39	42,961
2	20	19,600	3	0	32,400	3	40	48,400
2	21	19,881	3	1	32,761	3	41	48,841
2	22	20,164	3	2	33,124	3	42	49,284
2	23	20,449	3	3	33,489	3	43	49,729
2	24	20,736	3	4	33,856	3	44	50,176
2	25	21,025	3	5	34,225	3	45	50,625
2	26	21,316	3	6	33,596	3	46	51,076
2	27	21,609	3	7	34,969	3	47	51,529
2	28	21,904	3	8	35,344	3	48	51,984
2	29	22,201	3	9	35,721	3	49	52,441
2	30	22,500	3	10	36,100	3	50	52,900
2	31	22,801	3	11	36,481	3	51	43,361
2	32	23,103	3	12	36,864	3	52	53,824
2	33	23,409	3	13	37,249	3	53	54,289
2	34	23,716	3	14	37,636	3	54	54,756
2	35	24,025	3	15	38,025	3	55	55,225
2	36	24,336	3	16	38,416	3	56	55,696
2	37	24,649	3	17	38,809	3	57	56,169
2	38	24,964	3	18	39,204	3	58	56,644
2	39	25,281	3	19	39,601	3	59	57,121

APPENDIX C.- (Continued.)

Time of flow			Time of flow			Time of flow		
Min.	Sec.	Constant	Min.	Sec.	Constant	Min.	Sec.	Constant
4	0	57.600	4	21	68,121	4	42	79,524
4	1	58,081	4	22	68,644	4	43	80,089
4	2	58,564	4	23	69,169	4	44	80,656
4	3	59,049	4	24	69,696	4	45	81,225
4	4	59,536	4	25	70,225	4	46	81,796
4	5	60,025	4	26	70,756	4	47	82,369
4	6	60,516	4	27	71,289	4	48	82,944
4	7	61,009	4	28	71,824	4	49	83,521
4	8	61,504	4	29	72,361			
4	9	62,001				4	50	84,100
			4	30	72,900	4	51	84,681
4	10	62,500	4	31	73,441	4	52	85,264
4	11	63,001	4	32	73,984	4	53	85,849
4	12	63,504	4	33	74,529	4	54	86,436
4	13	64,009	4	34	75,076	4	55	87,025
4	14	64,516	4	35	75,625	4	56	87,616
4	15	65,025	4	36	76,176	4	57	88,209
4	16	65,536	4	37	76,729	4	58	88,804
4	17	66,049	4	38	77,284	4	59	89,401
4	18	66,564	4	39	77,841			
4	19	67,081				5	0	90,000
			4	40	78,400			
4	20	67,600	4	41	78,961			

THE PRESIDENT: I think we have all been pleased with Mr. Morehead's paper. I should like some gentleman, who feels competent to do so, to discuss it.

MR. FULWEILER: I wish to compliment Mr. Morehead very much on the vast amount of valuable information that he has gathered together in this paper, on a subject I think a great many of us feel has not received the attention that it should receive in the gas business. There are two or three points Mr. Morehead has either omitted or not put just the way I should like to see them, and I should like to amiably differ with him on a couple of them. In the first place, he says that this paper may be used as a text book; if so, I do not think he has been quite fair to the Hempel apparatus, because the illustration of the form of the Hempel apparatus which he has given us is archaic and probably does not exist outside of a

museum. I do not believe anyone has ever used it for the last twenty years and it does not bear any more resemblance to the modern form of Hempel apparatus with the manometer tube, and the jacketed burette, and the three-way cock so that the KOH bulb can be attached, than the very modern form of apparatus which Mr. Morehead has shown here resembles its originator. With modern Hempel apparatus such as I have described, analyses to the extent which Mr. Morehead has also described in here, can be made in about equal time, and some people think with considerably more accuracy and with considerably less slop due to wash water in the chemicals. I just bring that up in passing, because I think that the Hempel apparatus, while it has some disadvantages, is still a pretty good form of apparatus for general work. There is another point, going on into the discussion of illuminants in the constituents of the gas, Mr. Morehead rather would lead the unitiated to consider that ethane represented the illuminants. I find no mention at all of benzol in the illuminants. We have always felt that the value of the illuminants was to a very considerable extent due to the benzol vapors in them, and I think that in a paper that pretends to be a text book, the benzol should be spoken of, as it is decidedly important. In considering the oxygen and the reagents which are best adapted for its determination, Mr. Morehead thinks that an alkaline solution of pyrogallic acid is best for this purpose. I differ with him on that, as the action of the pyrogallic acid solution is a bit indeterminate, and unless you repeat back and forth and test it, it is very difficult to tell when it is through. On the other hand phosphorous is absolute in its action, and by the color of the vapors you can tell when the action has ceased. Moreover it has one very valuable characteristic, that traces of illuminants which could not be determined in any other manner can be determined by the absence of the sudden flash of vapors when passed over the phosphorous before passing into bromium. I think that is a very important point. It frequently becomes of importance when you are looking for traces of illuminants in

gas. In the first part of the paper he speaks about the determination of hydrogen by its combustion, by its action on palladium. He says that hydrogen is absorbed by palladium, but later he corrects that and speaks of it as being a method of combustion. I think it would be well in a text book to have the explanations correct throughout. Mr. Morehead speaks of the influence of ethane as affecting the analysis when the analysis is determined merely by explosion, and says its effect is negligible. I don't think he ought to let the Would-be Gas Analyst of the future go along with that idea in view, and he should be told that ethane has a very important effect,because if you will consider a gas mixture that contains actually 30 per cent. hydrogen, 12 per cent. methane and 4 per cent. ethane, and analyze by simple explosion, you will find that the analysis would come out 26 per cent. hydrogen, 20 per cent. of methane. This might lead to considerable differences in the interpretation of an analysis. While it is true that, regarding the calculated calorific value, this makes but little difference, that is merely proof of the fact that the coincidence observed and calculated calorific values do not prove that the analysis was correct. It is not necessary to go through all the work of absorptions to determine calorific value by analysis or by chemical methods. You can simply mix the gas with oxygen or air, and explode it, and by the oxygen absorption you can determine very closely the calorific value. Again Mr. Morehead says that KOH pure by lime is better for use than KOH by alcohol. I think it would be well to state that you should not use KOH by alcohol if you expect to get accurate results, as some action takes place there in the hydrocarbons which are left in the potassium hydroxide, which would entirely destroy the accuracy of the analysis. There is a very interesting thing here. Mr. Morehead speaks of the determination or identification of sewer gas by the H_2S present. That is a most interesting fact, and I would like to ask Mr. Morehead whether he has any data or knows of any case or thinks that the courts would accept that test as identifying the presence of

sewer gas. There have been cases in which it would have been extremely interesting if we had a method by which we could positively state that the sewer gas was present in a certain gaseous mixture. I do not know of any tests that are very accurate, and I should like to know whether he thinks that the courts would accept that method. There is another point. The absorption of carbon monoxide by the acid cuprous chloride solution I think, in general, is held to be somewhat of a mechanical effect, and that therefore it is theoretically impossible, even with the perfectly pure fresh cuprous chloride solution, to absorb all of the CO. You come to an equilibrium in which, for instance, you take a solution that has been used and put a little air in it, you can get a carbon monoxide solution, vice versa. Therefore in all analyses which do not combust the gaseous residue from the absorption over palladium, and thus determine the carbon monoxide as CO, and that corrected, you are liable to an error in the explosion. It seems almost impossible to get it out. Generally with coal gas, the correction in the residue will be about half of a per cent. of CO, and in water gas, where there is four times as much carbon monoxide as originally present, the correction factor and correction constant will run up to two per cent. sometimes; in fact, it will frequently run to two and one-half per cent., and I think it would be well to call attention to this source of constant error. Again, speaking of the determination of hydrogen by combustion over palladium chloride, Mr. Morehead speaks first of determining the hydrogen and then excluding the balance. Ordinarily I think we have found it much more accurate to determine that in one sample of the residue, and then make the explosion from a sample that has not had the hydrogen removed, because your results on exploding simply the mixture of methane, which is full of nitrogen, would seem to be not nearly as accurate as when you make an explosion containing the hydrogen; you get a much better explosion. Regarding the interpretation of the data I think the standard or average analysis which Mr. Morehead has

gotten up and the interpretation to be derived from these, are certainly of great interest, but in those interpretations I am free to confess I believe that judgment has a great deal to do with it, and on many of the points I do not agree with Mr. Morehead. Of course I admit one thing : That these standard analyses were made with Mr. Morehead's type of instrument, which gives, as I have shown, some different values, for, let us say, hydrogen and the methanes, and that may influence the interpretation, but otherwise I think a great deal of judgment has to be exercised in the setting down any hard and fast rule as to the interpretation to be derived from your analysis. Not that I do not think they are of great interest and of great value, but I think this: They should not be followed too blindly. There is one very important thing I think Mr. Morehead has omitted from his paper, and that is the fact that it is fairly easy, after a man has spent a year or so in making gas analyses, to make a fairly close gas analysis, but it is extremely difficult to get your sample. It is a little like the receipt for hare soup, which says, "First catch your hare," and I think the gas analysis in its most important part is, "First get your sample." They have been trying for a number of years I think, probably ten or twelve, to come to an agreement as to a standard method of getting flue gas samples, and I don't think anyone yet will admit that he really believes that a sample of flue gas that he gets by any of the ordinary methods is a true sample It may be and it may not be, so that I think he should call the attention of the would-be analyst to the difficulties which have to be faced in getting anything that even resembles a true sample. Furthermore, I think that he should not be allowed to think that analyzing gas is something which can be done easily, after reading a paper or a book, or seeing someone do it. I think probably the first three months a man works at gas analysis he may think he knows how to do it, and the next three months he begins to realize that there are some difficulties, and after he has been doing it about a year he begins to think that some day he will learn to be a gas analyst.

I do not think a man should be allowed to go away with the idea that it is easy. It is probably one of the most difficult pieces of chemical or of analytical work that anyone is ever called upon to do, and unless a man keeps his hand in day after day and week after week, I personally do not believe his analyses are worth the paper they are written on. They may look all right, but there is a great deal of doubt in everyone's mind about them. There is another thing that I think Mr. Morehead might have included, and that is, in his bibliography here I notice he has a great many methods of gas analyses and books on gas analyses. I am familiar with practically all of them, but it is my personal opinion that the most valuable paper on technical gas analyses that has ever appeared has been entirely omitted. That is, I mean, modern technical gas analyses, the way we really do it, and that is the paper that was read by Mr. E. H. Earnshaw, on the chemical analysis of water gas, which appeared before the Franklin Institute in 1898. I think that paper contained the basis of the most accurate commercial or technical methods of gas analyses that have ever appeared.

THE PRESIDENT: Gentlemen, your applause signifies that you have all been interested in Mr. Fulweiler's analysis of Mr. Morehead's paper. Are there any more gentlemen who would like to speak on that subject?

MR. CHARLES W. HINMAN: If this paper is intended as a handbook for young gas analysts, I should like to say a few words on the subject. The first criticism I should have to make would be that the paper seems to make it appear that gas analysis is quite a simple proposition when you know how, but some of us have been at it thirty or forty years and we do not know quite how yet. I think with any of the apparatus described, that what we may call the absorption analyses are quite fairly accurate. For example, carbon dioxide, illuminants, oxygen, and the subject of criticism that has just been made, carbon monoxide. I think the preferable way in absorbing carbon monoxide is to use two solutions, and give it a

good long soak, then you can come pretty near; but when you come to determine hydrogen, methane, and more especially nitrogen, by the ordinary water apparatus, I think you have to do it with extreme care, and the nitrogen is apt to be faulty. When I wish for accuracy I use the method of Bunsen and the apparatus of Williamson-Russell. I used it thirty or forty years ago, but it is quite a costly, fragile apparatus; it does not take so very much time, but using that apparatus and using mercury as a seal, I and my assistant made three analyses of illuminating coal gas, and the greatest variation in any constituent was about a quarter of one per cent., and most of them were within a tenth of one per cent.; but this mercury apparatus is too delicate to be used in ordinary routine work. When you come to determine the methanes, for example, by explosion, using water as a seal, you have to be very careful, or the water that seals the apparatus will absorb the carbonic acid formed, and so you get totally erroneous results. And perhaps as important a criticism as I could make would be on the determination of the calorific value from the analyses of gases. On page 328 there are given some coefficients for illuminants. These vary from about 1900 to 2250. Now, to arrive at any fair determination of the calorific value of illuminants, it is only necessary to know something of the constitution of those illuminants. For example ethylene, as I recollect it, has not half the calorific value of an equal volume of benzol vapor and still it has the same volume. I am speaking without notes and do not know just what it is, but know that it is something like that. And perhaps there are even greater discrepancies. So it is absolutely necessary to know something about the constitution of the illuminants. Mr. Jenkins, State Inspector of Gas of Massachusetts, attempted to do something in this line by analyzing the gas, and in one of his analyses of illuminants he determined the amount of carbon and the amount of hydrogen in the illuminants, and using those figures, he was enabled in a large majority of cases to come very close to the determination by the Junkers calorimeter. There were

one or two determinations where the determination was somewhat different, but generally speaking they were as near as you could ask. It is much easier, instead of having the two analyses to be required by the mercury apparatus, to use the Junker calorimeter in the first place. The only other criticism I have to make would be, his sample of coal gas given on page 311. It is not a fair sample of the coal gases I have been accustomed to analyze. Carbon dioxide is given as two and a half per cent. Hydrogen is lower. I have a memorandum of my recent analysis of the gas at Lowell which was somewhat different from that. I will read it if you do not mind:

Carbonic acid	0.07
Illuminants	4.06
Oxygen	0.00
Carbon monoxide	7.08
Hydrogen	52.95
Methane	32.24
Nitrogen	0.60

You will notice that the nitrogen given in Mr. Morehead's paper is 5½ per cent. I am inclined to think that that is partly due to the faulty method of analysis.

The President: Mr. Hinman has given us some further light on this paper. Is there any other gentleman who would like to discuss the subject?

Mr. Chas. J. Ramsburg: I think Dr. Elliott and Mr. Fulweiler have both gone a little too far in establishing the standard for the length of time it takes to make gas analyses. I do not mean at all to say that it is an easy matter, but I think it is a matter of personal equation as the first thing, and if you are going to get into gas analyses in your work, you need to pick out a man who has been well trained technically from one of the universities in chemical work and who has an aptitude for that kind of work. I should like to make two or three points in regard to Mr. Morehead's interpretation of the water gas analysis. Of course I realize that in a paper of this kind

it is impossible to cover all the points that may be made on the interpretation of analyses, but Mr. Morehead has left the impression that this water gas of 24 candle-power on page 321 is a representative water gas of 24 candle-power, and has not brought out the fact that to make an analysis of a gas of a definite candle-power, and to interpret that analysis, to show the results on a water gas machine, requires a pretty intimate knowledge of the analysis of gas from a particular oil: Gases made from oils from Texas, from Oklahoma, from Kansas, from Pennsylvania, or from Lima,—require different treatment. Each kind of oil must be handled in a different way; consequently there must be a certain amount of information in regard to the oil which is being used in the set. For instance, if I take up this analysis, after working for a number of years on this subject; and looked at this analysis here and knew that it was made from northern oil, I should say it was obtained with a very low candle-power, because the proportion of the methane to the illuminants is very large. In the breaking up of the oil gas in the machine, the proportion of the gas as it is formed is due to the heat to which that oil is subjected and to the time that it is maintained at that heat; and it is my belief, after years of study of the subject, that the analysis of this water gas, and the analysis of oil gas deduced from the analyses, will indicate largely the heats carried in the machine and the results being obtained in the machines; but you must know thoroughly what oil you are using and what analysis you are working to get on that particular oil. I should like to ask Mr. Morehead a question in regard to his statement: "An excess of methane would mean a low or dirty fire, too little steam, dirty checker-work, or overload, or a cold machine." I should like to ask him if he will not explain that a little. Also, "A deficit of illuminants shows an excess of blue gas or too little oil." Of course, in order to have a deficit of anything, you must have a particular object to be obtained in your mind in order to compare it with, and I do not understand whether he means to refer back to this analysis as being a standard analysis for a 24 candle gas; and

if by analysis you have not the illuminants shown in this analysis, it means that you have worked with a poor fire.

THE PRESIDENT: Mr. Ramsburg has given us some more light on this subject and added a little more to Mr. Morehead's responsibility. Are there any more gentlemen who would like to speak?

MR. MUELLER: There are one or two criticisms which I should like to make on this paper. Speaking of the effect of CO_2 on the candle-power of illuminating gas, I think the figure between 2 and 4 per cent. of CO_2 is, however, too low. I think between six per cent. and eight per cent. would be more nearly correct. Speaking of oxygen, he says: "The mixture of pure oxygen with gas would give a sharper, keener explosion of the gas engine, would give a higher candle-power." This is contrary to some tests which I have made which showed that the mixture of oxygen with gas even more detrimental than the mixture of nitrogen or air. And in his speaking of the effect of air on candle-power. I think the figures are a little too low.

THE PRESIDENT: Are there any more gentlemen who are going to discuss this paper?

DR. ELLIOTT: Mr. President and gentlemen, Mr. Ramsburg accused me of making a gas analysis complicated. I deny the allegation. I have aimed, ever since I have had anything to do with gas analysis, to make it simple, and I think the method which I have followed the past thirty odd years, and its general use, are in favor of my plan. I am not going to state the particular apparatus that I am an advocate of against the Hempel apparatus. I am very well satisfied that the Hempel apparatus will beat it for very fine work, but for rapidity I will set it up against Dr. Morehead and all the rest of them. All the modern apparatus that he has mentioned with regard to the absorption of the various kinds of gases, are about equally rapid in hands that are used to them. I have taught a large number of young men how to do this, and I am

satisfied that one man likes one apparatus and another man likes another. It is immaterial to me nowadays which they use. I am very well satisfied with my own apparatus. With regard to some of the criticisms that have been made of analyses. Mr. Fulweiler spoke of the presence of benzol. I agree with him, I don't think you can find a water gas made that does not contain benzol. I can always find it, and within the past year I have had an opportunity of making a number of tests. I did not determine benzol by any simple apparatus but put it through fuming nitric acid and made dinitrobenzol and analyzed it, so I knew it was benzol; I was not guessing at it. That is a tiresome job; you cannot do it in a day or a week. For certain scientific purposes it can be done. I want to take exception to one of the speakers who says that pyro is not as good as phosphorous. I have tried that many times and in my mind it is very hard to see the difference. Sometimes the phosphorous seems to be a little better than the pyro; sometimes the pyro will absorb oxygen better than phosphorous, but it is pretty hard to choose the better one when you are working in an ordinary way with rapid apparatus and you want to get results that the engineer needs right away. Now, with regard to samples I agree with the speaker when he said it is very difficult to get true samples. The only way is to get a number of samples. Now with regard to the explosion at the end. One of the speakers said that the nitrogen varied. I am afraid that that is due to the use of oxygen with the explosion. For some years I have omitted the oxygen in the explosion except the oxygen that was in the air. If you are careful to measure the air accurately, and if you do not use any more than the pretty nearly calculable quantity of air which you get from the first analysis, your nitrogen will come out very accurately; so that the difference in the analysis, the footing up of the analysis, and the actual measurement of the nitrogen left in the residue after you get through, will coincide within a few tenths of a per cent, but you must not use oxygen. If you do, you run the risk of exploding the nitrogen and

getting nitrogen compound. One thing about the carbonic acid and the water absorbing the carbonic acid after the explosion: I am afraid that is a good deal of a nightmare to some people. I have had a mixture of gas containing as high as 15 or 16 per cent. of carbonic acid stand over water in a gas burette all night with only a loss of one per cent. Now it stands to reason that while you are working at an explosion and you end it up in the course of fifteen or thirty minutes, there is not much chance for the absorption of carbon dioxide unless your apparatus changes temperature. Of course I am assuming that the apparatus will not change temperature, and under those circumstances there isn't any fear of the carbonic acid being absorbed by the water, and it is not necessary, unless for very accurate work, to explode over mercury. I have seen parallel analyses made with explosions over mercury and explosions over water, where the nitrogen would differ one per cent., but that is not very material. I would like to tell the story if I may, Mr. President, of how it was I got the apparatus up, the simple apparatus that I have been using. I met the president a good many years ago; when I first met him he inveigled me into the gas business. I was a chemical manufacturer at that time, and I remember one of the first gas analyses that he gave me to do. I took the sample about nine o'clock in the morning and I got through with it about noon, and he said, "What is this?" I said, "That is the gas analysis you gave me to do this morning." "Oh," he said, "That is no use to me now; I made a dozen since then." That took my breath away. I thought I was not going to be any use to him unless I could work quicker than that, and that night I devised the general principle of the apparatus that bears my name. I have made many thousand analyses for him, and I am proud of what I have done and I always felt that our worthy President has always encouraged me along this line of work. I think the chemist is now coming to his own, and I hope you gentlemen will appreciate gas analyses, and if you will carefully study them, as you do some of the problems that are

purely engineering, you will find great comfort in the gas analyses that you get from the chemists. And it is not so very difficult a job. A fairly educated man can get fairly expert at it in a very few weeks, and in a few months he ought to be doing very satisfactory work.

THE PRESIDENT: Who is the next one?

MR. J. B. KLUMPP: I do not want to spend any time criticising the paper, but I want to bring out a few points that I think were not emphasized sufficiently. My hobby is calorific value, and the title of this paper is the "Determination of Calorific Values from Analysis." From a number of reports of various companies received, Mr. Morehead quotes the heating value constants assumed for each gas. For the simple gases like carbon monoxide, hydrogen and methane we are all agreed as to the constants to be assumed, and we are quite sure that our analyses give us the gas close enough to find the total heat put in the gas by each one of these constituents; but, as Major Hinman said, the analysis of the heating value given by the illuminants is from 200 to 300 heat units, and if you have not an exact analysis of the illuminants and know what they are, you cannot assume any constant for them. I am afraid some of our members will use, for instance, the average value given in the 1908 report, Calorimetry Committee, as the heating value of the illuminants. It of course depends entirely how the gas is made and where it is made, and I do not think we can assume any value at all for heating value of the illuminants, I do not want any of our men to take an analysis and attempt to calculate the heating value and submit it for commission work or commission inspection, because they are likely to be anywhere from twenty to fifty heat units out, but if you are making gas under the same conditions every day and you determine that constant, using the same materials in a calorimeter, you can use it approximately for the next three or four days running on the same gas. But our gases are so changeable; if we are making a great deal of water gas, the benzol and the ethylene are all determined on the same

analysis and the same figure, the heating value is very different from benzol gas received from long distance where the candle-power is determined by the high percentage of benzol; I just want to impress the fact on the members that you cannot calculate the heating value with any degree of accuracy from the analysis, unless you know absolutely the conditions where it is made. Do not attempt to try to use these figures for commission purposes; they will do all right for your own work and for comparative purposes.

THE PRESIDENT: We are obliged to Mr. Klumpp for his remarks. Is there any other gentleman who would like to speak on this subject? It seems to be rather a prolific one.

DR. F. SCHNIEWIND: I was also very much impressed with the paper by Mr. Morehead, and wish to make a few remarks. In the first place, I was very much astonished at the great variation in the physical and chemical constants for the constituents of gas which were reported by the various gas companies. What is the reason for this? I believe the cause of it is to a great extent to be found in that the various investigators do not report the sources from which they have taken these physical and chemical constants. I think that Mr. Morehead would greatly add to the value of his paper if he makes these public also, because only in that manner is it possible to judge as to the value of the physical and chemical constants given. Now in regard to the reports on the analyses, these are given in the form, as regards analyses, as the gas analyst obtains them in that report; in this way they are of very little use to the gas man. I would suggest that this report be changed and reported in the following rotation: First, the illuminants and the analysis of these, going into details, then report the benzols and its homologues afterwards, and the methanes and the homologues of that; second, which I believe would be in the order of their importance, methane, hydrogen and carbon monoxide; and finally the impurities, that is, carbon dioxide and nitrogen and oxygen, which is of very little importance. Now finally I want to say that in the report on

coal gas Mr. Morehead says, "Carbon dioxide is generally due to leaks in the retort." That is hardly the case. We have found, for instance, that in the beginning of the carbonization of coal when the retort is under the highest gas pressure, the per cent. of carbon dioxide is the largest. There the chance for inclusion of air from the outside is the least. The carbon dioxide is the product of the decomposition of the coal and especially is produced in the largest quantities in the beginning when the temperature is low. I should like to have also, in addition to the coal gas, to have seen an analysis of coke oven gas for comparison.

THE PRESIDENT: Are there any other gentlemen who would like to make criticisms or remarks? If not, we will give Mr. Morehead an opportunity to clear himself.

MR. MOREHEAD: I am glad that I have one friend, who says he is glad to see that the chemists are coming into their own. The chemist has taken the horseshoe from over the door of the retort house. The object of this paper is to try to give a little more scientific basis to the manufacture of gas by the use of chemical analyses. When I started to write this paper I outlined the method to some of the men in the laboratory in Chicago, and thought that we would get a holder and fill it with gas, and keep the gas until we were sure that the changes had stopped taking place, and that then we would make a series of analyses by different methods and by different apparatus and by different chemists, and try to find which was the best for small differences which did exist. It fact we made some analyses, using plain water, and distilled water, water saturated with air, and water saturated with gas, but when I sent out these papers and they began to come back, and out of 220 sent out only 31 reported regular gas analyses, I realized that they did not want anything about these fine differences in methods, but they needed to be told that analyzing the gas is a good thing. With the exception of the United Gas Improvement Company, the Chicago people, and

the Consolidated Gas Company of New York and the companies attached to them, the practice of gas analysis was really very limited. When it comes to discussing the difference between pyro and phosphorous for oxygen, the use of either one of them is infinitely better than not making any gas analyses at all. The gentleman who spoke for the Hempel apparatus will notice that on page 266 it says: "In the first class is Hempel's apparatus, which is perhaps the best known of the more accurate instruments. In experienced hands it gives excellent results, but the first cost is high, owing to the number of different parts it is liable to breakage, and a complete analysis by it requires quite a long time." The pictures given were some which were furnished by the manufacturer, but nobody would order a Hempel apparatus from these pictures, and it was merely diagrammatic in any event. I think most of the gentlemen did not get the drift of the intention of this paper. It says: "It is not the intention of this paper, nor within its scope, to suggest different lines or methods of gas analysis, or to suggest changes in existing practice where such practice exists, or to draw comparisons between different designs of apparatus. There is practically only the one method and it is quite sufficient. With any of the modern types of apparatus consistent and valuable results can be obtained." Now the rules which were given were those used with the apparatus which we have had the past six years in Chicago. I wrote to some of the other gentlemen who were responsible for gas analyzing apparatus and asked them if they would send me the methods of analysis with their apparatus, that I should be very glad to incorporate them but I did not hear from them. So far as the question of the exactness of these analyses given, I disclaim their accuracy in every case. The paper says, "The following figures are not given as absolute standards for all cases, but are averages of those figures which under certain local conditions obtain in the best practice." Now, there are four out of seven constituents in a gas which influence the heat units. These are CO, methane, the il-

luminants, and hydrogen. Three of these you can get with accuracy. We have determined this—I presume most people who have experimented along these lines have—you can make each of those four constituents in a chemically pure state. You can determine them with a great deal of accuracy and they agree. Now the illuminants do not agree; they are never twice alike. They are not the same in the same gas or in different gases, and to get any kind of an agreement with the calorimeter, which I consider the standard, you have got to make your analysis, calculate your heat units from the three that you know and establish your own constant for the four By doing that, it says, rather distinctly, you will get a constant of your own which will enable your analysis to agree closely with the calorimeter. One gentleman thought it would not be well to take value of the illuminants given on page 328 as an average. Now, instead of that I would suggest that on page 328 there are several different values for illuminants given. There are the illuminants which occur in Pintsch gas, in 28 candle-power water gas, in 24 candle-power water gas, in oil gas, in 20 candle-power mixed gas, 16 candle-power coal gas, gasoline gas and acetylene gas. I find the proportion which would be absorbed by bromine and reported as illuminant varies in all of those cases, but these figures will give a very close agreement with the calorimeter, but it will not be right to take a constant for Pintsch gas with illuminants which would add 2,500 heat units, and use it for natural gas, whose illuminants would add about 1,500. You have to establish those for yourself. Now, the other gentleman spoke of pyrogallic acid in the burette. You would not know when you have used enough. In the form of apparatus designed by Dr. Elliott, and the same in my design, you do not use the same chemical over and over; you use new chemicals all the time, the gas is stationary and the chemicals can be going through. It is not like the Hempel or the Orsatt-Lunge apparatus, where you put the gas back and forth through the same chemical. Mr. Fulweiler spoke of the article by Mr. Earnshaw not being

mentioned. That is quoted fully in Abady's Gas Analysts' Manual, which is mentioned in the bibliography. So far as saying acetylene does not occur in gas, it does. The very first mention of acetylene that I ever heard of—and I was present at the birth of it—was a jug of alcohol at the Centennial Exposition in 1876. The alcohol was made from acetylene that came out of coal gas, and until the discovery of calcium carbide in 1892, that was about the only mention which you could find of acetylene. It does exist, but this is an analysis of the industrial gases, if the gentleman will look on the first of the page, he will see "Industrial Gases." That does not mean the academic analysis of gas. You can go through a gas analysis and find almost anything. There is almost anything in the chemistry books under the head of illuminants. If you want to go and look this up, you can take as long as you want, but for industrial purposes 33/100 of one per cent. of any one constituent does not cut much ice around a gas house. All of the figures given are carried to 60 degrees F and 30 inches of mercury, and based on dry gas. As to sewer gas I find—I don't know what action the courts would take—but in the gas business you always hear two things. One man says there was an explosion. The gas man immediately says "sewer gas! That is one of the first lessons in the gas business. All of the illuminating gas which is put out has been purified until there is no hydrogen sulphide in it. You do not get any stain—presumably. Sewer gas does contain a very large per cent. of hydrogen sulphide and often I have made that test and used acetate of lead paper the same as we use in the purifying house. Silver nitrate is a little more accurate than lead acetate. What action the court would take I cannot say, but it is a very good indication of the presence of sewer gas. The gentleman was right in saying that the absorption of CO by copper is mechanical. It is, but with this particular form of apparatus which I use, of the class which Dr. Elliott's apparatus and my own belong to, the new chemicals keep going through the same gas and you

can come very near seeing how far the absorption has gone. You ought to take a little longer with that, and the way people do ordinarily is to put the sample in the burette, put your copper chloride in the funnel and just crack the stop-cock at the top and let it drain in, then go and take your photometer reading and when you get back the solution has had ample time to do all of its absorption. A large number of these analyses are taken from our own experience and a number of them are checked up with the check analysis which the gas company chemists were kind enough to send us. So far as the exact analysis is concerned, where a man is making seven determinations in thirty minutes, you cannot expect him to split hairs. There may be men who can make an analysis and get it to within one-tenth of one per cent., but it would be history; you would get it day after tomorrow and your gas would be gone. There is always the personal equation, and in almost all of the interpretations which show an excess of oxygen, it says that there was perhaps carelessness in taking the sample, and care in getting your sample is something which cannot be overestimated. So far as the accuracy of the analysis is concerned, the Junkers calorimeter gives you a good check. If your constants are correct and when calculated out agree with the Junkers, then your analysis is right; if they do not agree, one or the other is wrong. On these pages which are added in the back, you will find places for the calculating of heat units from the analysis. If a man will take the trouble for a week to establish his constant for illuminants, he can come very close to it indeed. So far as nitrogen at the end of the analysis is concerned, nitrogen is about the only thing in the group of chemicals which will stand the racket that the residue goes through with. It is treated first with an alkali and then with an acid, and then to an explosion with pure oxygen, and what is left is bound to be nitrogen. There isn't anything else in the chemistry book that I know of that would stand all that grief. If you have a very rich gas, you don't want to use oxygen; take a gas as

rich as acetylene, put oxygen in and explode it, it blows up your burette. The illuminants, as I have said, a man has to calculate for himself, but with these figures that are given here under the particular gas on page 328, you can come to a very close agreement, and where a man has two instruments, why use them? If you have both, you had better stick to the Junker's; if you have the analysis, you can use one to check up the other. If you cannot pay $125 for a Junker's apparatus, you had better buy Dr. Elliott's apparatus, make your analysis and calculate from it. The oil would apply in the same way. Too much oxygen will unquestionably take candle-power out of the flame just as too much air will, but a small amount of it will increase the candle-power in an open flame. This paper says that Dr. Elliott's apparatus is perhaps the best known. I differ with the Doctor a little as to the time required for an analysis. I will take the Doctor on and analyze gas for the championship! The gentleman from New England spoke of the CO_2 in his gas; that I think, at first when the heat is highest, would come from the air which is in the coal. The analysis which he gives of coal gas, with no nitrogen, practically no oxygen (only six-tenths of one per cent.) is remarkably good analysis, I should say from that that he does not have enough oxygen for his purification. I don't know what apparatus he uses. The analysis of the exhaust from a gas engine will tell you a great deal. Flue gas analysis will tell you a great deal. When you have trouble with the gas engine and the gas bill is too high, you can go and get a sample of the exhaust, maybe five times out of ten, certainly three times out of ten, you can find what is the matter with it. The mixture is wrong and the man that is running the engine does not know it until you make the analysis and tell him. In flue gas analysis, a man will take the analysis and look at it and tell you right away what the trouble is. It is real uncanny sometimes to see a man that is thoroughly familiar with it; we have men there that will look at an analysis like that and say "Your superheater is too hot."

They get familiar with standard analyses, and any small variations indicates something to them.

MR. MCDONALD: I move a vote of thanks to Mr. Morehead.

A vote of thanks was then duly passed.

THE PRESIDENT: We will now listen to the report of the

NOMINATING COMMITTEE.

CAPTAIN MCKAY: The committee nominates unanimously as follows:

For President, Donald McDonald, of Louisville, Ky.

For Vice President, W. Cullen Morris, of New York.

For Second Vice President, J. D. Shattuck, of Chester, Pa.

For Secretary and Treasurer, A. B. Beadle, of New York.

For Directors to serve two years:

W. G. Africa, Manchester, N. H.; W. R. Addicks, New York City; R. C. Dawes, Chicago, Ill.; V. F. Dewey, Detroit, Mich.; and J. M. Morehead, of Chicago, Ill.

THE PRESIDENT: Gentlemen, you have heard the report of the nominating committee. Are there any further nominations, none appearing. What is your pleasure?

MR. WILLIAMSON: I move that the report of the nominating committee be received and the secretary be instructed to cast one ballot for the names recommended by the nominating committee.

The motion was seconded.

THE PRESIDENT: Gentlemen, it has been regularly moved and seconded that the report of the nominating committee be received and that the secretary be instructed to cast one ballot for the names presented by the nominating committee. All those in favor of the motion will signify it by saying Aye those opposed, No. The motion is carried. The secretary will cast the ballot.

THE SECRETARY: Mr. President, I cast the ballot of the Association for the candidates nominated by the committee.

THE PRESIDENT: I now call upon the tellers, Mr. Nettleton, Mr. Woodall and Mr. Miller to canvas the vote and report.

MR. NETTLETON: Mr. President, the vote is counted and is cast as stated.

THE PRESIDENT: Gentlemen, the tellers have reported that the ballot has been cast for the names presented by the Nominating Committee. That being the case, I declare them duly elected. If the President-elect Mr. McDonald, is in the room, I am sure we should like to hear from him.

MR. MCDONALD: Gentlemen, I can say truthfully that this honor is unsought, unexpected, but surely not unappreciated. I can honestly say that if all the Colonels in Kentucky were to get together and choose me as Governor of that state I should not appreciate it as much as to have been picked out by the men in my own line of endeavor to represent them for a year in the Chair which has been held and made so illustrious by the men who have preceded me. I am not vain enough to think that I have been selected on account of my great scientific attainments. If the matter were left to a competitive examination, as the Japanese and Chinese do, there are four or five hundred men in this Institute who could fill this position as well if not better. Your action simply means: "McDonald, you are a good fellow and we are glad to confer this honor upon you." I wish to say that I intend to do all I can to advance the interests of this Association. If there are any cliques or factions in the Institute I do not know about them, and I have good friends among them all, I am sure. What appointments I make will be made without reference to them and as far as possible for the best interests of the Association. If the various men who have the interests of the Association at heart will suggest to me men heretofore not prominent in its affairs who will make good men for certain positions, I shall be glad to consider those men, and consider them with an eye not to conferring personal favors, but with regard to the best interests of the Association. I thank you from my heart.

THE PRESIDENT: Gentlemen, you have heard from the next president. I am sure we are all to be congratulated on his election. The First Vice President, Mr. Morris.

MR. WILLIAM CULLEN MORRIS: Mr. President and gentlemen, I am not very much on speechmaking, and did not expect to have to make one. The only thing I wish to say is that I desire with all my heart to be able to help the newly elected president carry out the sentiments which he expressed just a moment ago.

THE PRESIDENT: The Second Vice President, Mr. Shattuck.

MR. SHATTUCK: Mr. President and gentlemen; I thank you for the honor you have conferred upon me. I shall do all I can to carry out the duties required of my office and assist Mr. McDonald in the program that he has laid out.

THE PRESIDENT: The nominating committee sent a request to me that they wish to submit a supplemental report. It is about the procedure of the Committee. If there is no objection we will hear from the Chairman of the Nominating Committee.

CAPTAIN MCKAY: The Nominating Committee recommend that the Institute provide in its by-laws, or in amendments thereto:—

1st. That the Nominating Committee be designated at least thirty days before the annual meeting of the Institute.

2d. That the Nominating Committee be empowered to fill vacancies that may occur in its membership through declination, resignation, or inability to serve in person.

WILLIAM E. MCKAY, *Chairman.*

THE PRESIDENT: That involves, I think, a change in the by-laws or the constitution.

MR. A. E. FORSTALL: I move that the supplemental report of the nominating committee be received and referred to the directors for action.

The motion was seconded.

THE PRESIDENT: It has been moved and seconded that the supplemental report of the nominating committee be received and referred to the board of directors for consideration.

DR. HUMPHREYS: I do not know whether I am in order or not, but is it possible to give the directors power to act? If so, I would so suggest, as an amendment.

MR. A. E. FORSTALL: I would say that my original motion as made was that it be referred to the directors for action.

MR. MORRIS: That is what I seconded.

THE PRESIDENT: You moved that it be referred to the directors for consideration, whether they have power to act or not.

MR. MORRIS: If I understand, the intention of Mr. Forstall's motion was that action should be taken by the directors.

THE PRESIDENT: Shall we take it upon ourselves to tell the directors what to do?

MR. MORRIS: I think it is a function of that body.

MR. MCDONALD: We can get a provision to do something without directing them what to do, a motion that their action shall take effect before the next meeting, instead of waiting until this can be voted upon by the next meeting.

DR. HUMPHREYS: It is not my intention to direct the directors, but to give them the power to say yes or no.

THE PRESIDENT: Section 57 of the Constitution, under the heading "amendments," says that all propositions for adding to or altering any provision of the constitution shall be laid before the directors who, if they see fit, may bring it before the next general meeting of the Institute, and who shall be bound to do so upon the requisition in writing of any ten members of the Institute. All such propositions shall be decided by ballot and require two-thirds of the vote cast for their adoption. As this, to my mind, involves a change, I should say the proper motion would be to refer it to the directors for their action.

MR. MCDONALD: These reports made on the floor are in obedience to the constitution or by-laws. If it is a by-law, it seems to me we can amend it in the way we have designated.

MR. A. E. FORSTALL: The Constitution merely says that previously to each annual meeting the directors shall appoint a nominating committee; it says nothing at all about the length of time previous to it that they may have to appoint. This is merely a change in the by-laws, or possibly merely a change in the custom.

THE PRESIDENT: (Reading:) "Previous to each annual meeting it shall be the duty of the directors to appoint a nominating committee of five members." Whether it shall be one year previous or six months is not specified.

MR. MCDONALD: In order to carry out the idea that the nominating committee has put forward, I offer a resolution that it is the sense of this meeting that the report of the nominating committee should be made thirty days prior to the meeting.

DR. HUMPHREYS: I second that.

MR. MCDONALD: *Appointment* of a nominating committee shall be made thirty days prior to the meeting.

DR. HUMPHREYS: I second it.

THE PRESIDENT: Do you wish to withdraw your motion?

DR. HUMPHREYS: I withdraw my motion.

THE PRESIDENT: It has been regularly moved and seconded that it shall be placed upon the record as the sense of this meet- that the nominating committee for officers shall hereafter be appointed at least thirty days previous to the annual meeting. Are you ready for the question?

The question was called for and upon vote, was unanimously carried.

CAPTAIN MCKAY: The other recommendation is even more important, which is that the nominating committee be empowered to fill the vacancies in its membership that occur through declination, resignation or inability to serve in person.

THE PRESIDENT: Gentlemen, we overlooked one of the recommendations of the committee—that the nominating committee be empowered to fill vacancies that may occur in its

membership through declination, resignation or inability to serve in person. Will you make that also a resolution as being the sense of the meeting?

MR. MCDONALD: I don't agree with the idea that this resolution conveys. It seems to me it is just as well, if we appoint a nominating committee of five, and two of them cannot serve, for the remaining three to act without them as it is for those remaining three to choose two other men in their places, because it is just as easy to accomplish a certain object by three of them voting for what they want as it is to appoint two other fellows who will vote their way. In other words, every committee that has a quorum present can act. It seems to me the motion is unnecessary and unwise.

CAPTAIN MCKAY: In explanation of some of the difficulties under which your committee has acted this year, we were very desirous of submitting a unanimous report. We felt that the composition of the committee was representative geographically and in other ways of the Institute. Communication with San Francisco is somewhat difficult and we were for that very reason, compelled to postpone submitting our report of the Institute at its first session. Now I believe that if the men who are placed on the nominating committee by the board of directors have been chosen with discretion by the board, that they ought on the part of this Institute to be fair enough to fill the vacancies that may occur, fairly; and I do not think that you are giving them any undue power, and you are affording them an opportunity officially to settle the question of submitting the nominations to the Institute. If it be thought better that the directors should act in this matter and fill the vacancies, that can be done, but it would be a very slow and tedious process. You cannot get the directors together as easily as you can the members of a small committee of this kind. I am sure we should have been—or tried to be—perfectly fair in filling the vacancies. In other words, it should have been and would have been our intent to appoint or designate to fill those places men who, as nearly as possible,

represented the same interests or the same purpose and locality; and I believe that any succeeding nominating committee would try to do the same thing. I do not think you are giving them undue power. We could have submitted a report signed only by the three but we preferred to submit a report signed by all five, and I think that is the kind of report you want submitted on behalf of the nominating committee.

MR. MCDONALD: Wouldn't it be a better idea for the directors to elect a nominating committee and then elect five alternates, and choose those alternates in their order, in case anyone fails to serve or fails to show up? I do not think any nominating committee would want the responsibility of adding members to their own number.

THE PRESIDENT: Is it not the case that all committees are governed by the majority? In a committee of five, if two members are absent, the other three are a majority and can act.

MR. MCDONALD: It has just been expressed that the three might feel a delicacy in acting, and if there were alternates selected, they could act, and it would be just as easy to pick out ten as five and let the five be the committee and the other five alternates. It is done in all political matters.

DR. HUMPHREYS: I move that the second suggestion be referred to the directors for their consideration.

MR. MCKAY: The Committee concur in the substitute resolution of Mr. McDonald. I think it would be the better plan to have the alternates elected and designated in their order, so that in case of absence on the part of regular members of the committee, they can be called in, but it is not the same as a majority report from any other committee; a minority report from the nominating committee means two tickets in the field, with corresponding trouble.

The motion of Dr. Humphreys was seconded.

THE PRESIDENT: Gentlemen, it has been regularly moved and seconded that the second recommendation from the nominating committee be referred to the directors for their consideration and action. Are you ready for the question?

The question was called for, and on being put to a vote, was carried.

THE PRESIDENT: I want to get back to the schedule. The Chairman of the Beal Medal Committee, I think is ready to report.

BEAL MEDAL.

Dr. Humphreys then read the following report:

Your Committee appointed to award the Beal Medal for the year 1908 beg leave to report that they have decided in favor of

Walter Herbert Fulweiler

for his paper entitled

"The Physical Theory of Coal Carbonization."

It is only fair to the authors of other papers, and the members of Committees reporting on technical subjects, to say that it has been found most difficult to come to a decision by reason of the high quality of Committee Reports and other papers submitted at the same meeting.

WALTON CLARK.
B. W. PERKINS.
ALEX C. HUMPHREYS, Chairman.

THE PRESIDENT: Gentlemen, you have heard the report of the Committee on the Award of the Beal Medal for the best paper for the 1909 meeting. What is your pleasure with regard to the report?

MR. WILLIAM CULLEN MORRIS: I move that the report be accepted and placed on file.

The motion was duly seconded and carried.

THE PRESIDENT: Mr. Fulweiler, I congratulate you on your receipt of the medal.

MR. FULWEILER: Mr. President and gentlemen. The honor is indeed unexpected, but as our newly elected president said, not unappreciated. I think that one of the greatest rewards that can come to a man in the gas business is to feel that this Institute has honored him with its approval.

THE PRESIDENT: Gentlemen, the next paper on the list is

THE PUBLIC DECEIVED BY FAULTY DATA AND MISLEADING ANALYSIS OF DATA.

BY DR. A. C. HUMPHREYS.

Dr. Humphreys then read his paper as follows:

THE PUBLIC DECEIVED BY FAULTY DATA AND MISLEADING ANALYSIS OF DATA.

The time has more than come for plain speaking in regard to the way in which the Public is being misled as to the operation of our industrial corporations and especially those engaged in public service.

For this and other reasons I was greatly impressed by an address delivered last March by Duncan MacInness, C. P. A., of the office of the Comptroller of the City of New York. Let me quote a few lines particularly pertinent to my present subject: "All the elements and factors in the financial and business world are so closely inter-related and interdependent that at no time in the history of our country was the importance of *publicity, which conveyed a meaning,* so great as it is at the present day. It would be a great benefit indeed to the public if the statements and reports of every corporation, financial and commercial, in which the people have an interest as investors or depositors, *were published in a form that would convey a clear and explicit meaning as to its status and also as to its earnings.* Such statements of efficiently and honestly managed concerns would dispel the gloom of doubt that beclouds our financial horizon, and allow the rays of confidence to again illume the great business world." (The first italics are the author's, the second are mine.)

The course of events during the past few years should convey the lesson that publicity given to statements about our corporations which fail to convey a correct, clear and explicit meaning are dangerous in the extreme, and especially so

in view of the present attitude of the public mind towards financial, commercial and industrial corporations.

There is here a grave responsibility resting upon the authors of such publications whether they be corporation officials, government officials or self appointed guardians of the public weal.

Not only should all possible care be exercised in the preparation of statements and reports intended to meet specific requirements, but equal care should be exercised in the preparation of volunteered statements. And further, those who are looked to by the public to guard its interest should be as ready to publish facts which indicate good intent and efficient management on the part of the corporations as to publish those facts which admit of interpretation unfavorable to the corporations. Not only should such statements given out to the public through the press be correct as to fact, but the utmost care should be exercised to put the facts in a form to prevent as far as possible misinterpretation and misrepresentation. Subordinates should not be allowed to give out such statements to the Press except under the direct supervision of those who are and can be held responsible.

Apparently the Public is no longer prepared to see both sides of the many complicated problems involved in the management of our business corporations. Influenced by the professional reformers, the amateur reformers, the muck-raking writers for profit, the self-seeking politicians and some members of the judiciary, the Public is prompt to recognize and condemn not only the definite evils introduced by unscrupulous promoters and others but also the lesser evils necessarily present in some measure through the frailties of human nature. The Public is misled to look for perfection where perfection is not attainable and refuses to believe that the majority of those responsible for the management of these corporations also condemn these evils and are working faithfully and constantly for their correction. It fails to recognize

that the far-sighted investor is entitled in many cases by reason of extraordinary risks taken, to more than a minimum return (the professional reformer's "fair return") on his investment. While we may all join in condemning and opposing the methods so often pursued by reckless or designing promoters, yet, if it is our desire to face all the facts, may we not recognize that even these men have not infrequently benefitted the country by anticipating its needs and providing for them,—to their own profit, it is true. Certainly then, when the country has reaped these benefits through the foresight, courage and persistent efforts of honest and farsighted men let us not deny them their reward nor condemn them because of their success.

Is it not inconsistent to boast of our nation's material prosperity and then refuse to recognize that this great territory could not have been developed and covered by a network of railroads if the inducement to investors had been limited to the reformer's "fair return?"

Has not the time come for the Public to recognize that the tearing down of established industries, the constant dealing in destructive criticism, must of necessity result in injury to all the workers of the country, including the wage earners as well as their employers? Has not the time come to undertake seriously the reform of irresponsible reformers?

Conservation of our natural resources, so long neglected, is holding the attention of the people to-day. Shrewd politicians have found in this movement an effective rallying cry. Conservation of all of our resources is all important and is greatly needed. But this movement should not be confined to the forests, minerals and waterpowers, but should also serve to conserve the productive powers of Capital.

Do the conscientious reformers wish to build their reforms upon the treacherous foundation of misinformation and deceit? Is not the investing Public, which includes all who do not live up to their incomes, entitled to the truth as to the operation

of our great industries? Furthermore, are not those who are interested in these matters students in civics and economics entitled to the truth? All those who claim to be honest in their studies should do their utmost to gather the truth from material furnished to them, and should refrain from hasty conclusions derived from superficial indications and investigations.

Largely through the influence of one man, tremendously forceful but distinctly lacking in judicial qualities of mind and temperament, snap judgment has become alarmingly prevalent in this country. Acting under this influence, reform movements, so-called, have been undertaken with the attention centered on the insolated problem, without regard to other considerations involved in connection with the general good of the community and the country. Established laws when found to interfere with these movements have been condemned together with the judges who have endeavored to interpret correctly and enforce these laws. This is a manifestation of the very human tendency to take the law in our own hands when in our unwisdom we find the restraints of law preventing us from reforming according to the impulse of the moment. It is the mainspring of lynch law: and lynch law and mob rule are to-day being encouraged in this land through the unguarded and indiscriminating denunciation voiced by reckless men.

The guiding aright of the Public, the building up of a more judicial frame of mind on the part of the Public, is one of the responsibilities of all broadly educated men, and especially of those who are particularly qualified by education and practical training in the lines which are for the time under discussion. When I speak of educated men I do not mean those who depend alone upon what the schools and colleges can give.

The politicians, and even those who would wish to be appraised as statesmen, are over-sensitive of public opinion. Instead of trying to guide aright the Public, they are keen to

do and say, especially the latter, the thing which for the moment will attract the notice of and best please the Public—the Public which judges so largely by surface indications.

Therefore it becomes all the more necessary in the interest of good citizenship and self-protection, that those who are not selfishly interested in the political game and are in any degree qualified to influence rightly public opinion, should express themselves with intelligence and force, and so leave open to those who are keen to gain the public ear for their own selfish purposes, fewer opportunities to act the part of demagogues, a part all too popular in this year of grace 1910.

Some of my hearers will bear me out when I claim to have been for many years an advocate and worker for fair business methods and especially for a constantly careful regard for the rights of the Public. I have been a consistent advocate of a harmonious blending of theory and practice and have not infrequently been forced to fight the battle of the theorist. But the day has come when we must recognize that there is in this country too much theory. And here I do not have to recede in the slightest from any position I have taken in the past, for I have always contended that the theory must be complete, must take account of the practical conditions necessarily to be met, and especially must take account of the complex and contradictory make-up of the average human being, the agent necessarily to be employed in practically testing any suggested theory. I have always contended that if I had a chance to choose between the inexperienced and non-practical theorist and the non-theoretical practitioner, I would choose the latter, though further holding that the day had come when to live up to his responsibilities in connection with the world's activities the practical man should be a patient and sympathetic student of theory.

Today the country is loaded down with theories promulgated by men, yes and women, many of whom would be found incapable of earning a fair living if left to shift for themselves. We find government officials drawing comfortable salaries for

exercising control of the operations of corporations in many and varied lines of industry who, if left to their own resources as actual producers in a *single* line, would have difficulty in earning a scant living for themselves and their immediate families.

You may ask me to be more specific in suggesting remedies, remedies for which we are responsible, collectively and individually. I can only say that it is for us in connection with our vocations, and as other opportunities occur, to apply our knowledge and training in testing and, if need be, correcting the statements given out so authoratatively by those whom we may have reason to believe are unqualified to lead, and *not to be held back because we may fear that our personal interests may be so jeopardized.* To those who are inclined to be over-cautious let me suggest that the majority of men and women respect courage and fair play. People will follow a brave man even when it should be evident that he is leading them astray and that his courage is not coupled with straightforwardness and intellectual honesty. There have been of late in this country notable cases of this kind; men so astute as politicians as to recognize that the temper of the Public made it safe for them to depart radically from the truth and the more secretive methods of the ordinary politicians and so come boldly into the open if it was to lead the people against any established interest, good or bad. If then we have the facts to support us, certainly we should have the courage of our convictions.

Let us also remember that if we do not speak out as we believe, those who are placed over us by governmental authority are deprived of opportunities to learn where they are wrong and may so be more likely to proceed to further indiscretions and injustices.

I am reminded of a professor who by reason of the increasingly high character of the answers to his very difficult examination papers, year after year increased the severity of his examinations until students who would not cheat in any other department felt justified in cheating in his examinations.

A conscientious student appealed to me just before his examinations and said it was apparent from the reports handed down from previous classes that he must either cheat or accept a condition. I told him— "Not so, tell the facts frankly to the professor." He did so and the professor was horror stricken and later excused himself to me by saying—"The boys passed such fine examinations that I imagined I had underestimated their capacity and so I made the papers harder each year: how was I to know that they were too hard or unfair if the students made no complaint?"

I take it that dealing with fair men we need not fear antagonizing them by honest criticism and candid expressions of differences of opinion. If they are not fair men, then we might as well bring on the conflict as quickly as possible and so learn where we really stand. Such has been and will be my line of procedure and I do not expect thereby to sacrifice the good opinion of any whose good opinion I value.

To be more specific, as is to be expected in a paper before a body of practical men, let me cite by way only of example, a few of the many cases which have come under my eyes during the last few years of Public Service Corporation management, and particularly in connection with Public Service Commission control.

I imagine that most of us believe that a measure of control through such Commissions, provided it is properly limited, is to be welcomed. Years ago many of us advocated such control that we might at least gain freedom from the promoting raider and his greedy partner in the legislature, a partnership which continually demonstrated by its operations that we did not enjoy the monopoly charged against us. But we did not expect to have both Legislature and Commissions to deal with. Nor did we expect that the Commissions would be given power and authority in the three branches of government—legislative, executive and judicial—the three branches which according to our own form of government should and must be kept separate and apart. Let it be understood that

as a general proposition I am not opposed to Public Service Commissions, but I do hold that their control should be confined within far narrower limits than at present: and I venture to prophesy that unless this is done—that if control by Commission is permitted to develop along the lines as at present, including the three departments of government named, we have seen the beginning of the end of our form of government.

In any case we cannot expect that the members of a commission authorized to control public service corporations in several lines of activity will be found competent in all of these lines, including the refinements of construction and management: assuredly not unless the members are selected for their training in practice and theory as well as for integrity. We may well take a lesson here from our cousins of Great Britain who recognize in this connection that other qualifications are required in addition to those obtained through legal training. And yet in connection with government by commission we too often find men without practical experience not only willing but anxious to decide questions which cannot be determined safely without full experience coupled with good judgment. They rush in where angels would fear to tread.

Too often members of our Commissions have shown a disposition rather to encourage than discourage the hostility between classes which has of late been so much in evidence.

The gas men of Massachusetts and we of the Second District of New York are therefore to be congratulated that the Commissions to which we are subject are earnest in their efforts to prevent troubles and to adjust difficulties between the public and the corporations, rather than to cultivate them.

Have we not the right to demand that our governmental bodies—commissions, legislative investigating committees and the like—and students of economics, should be careful and conscientious in the extreme not to spread misinformation through faulty data and statistics and through the incompetent analysis of even correct data? But it must be admitted that

such has often, yes generally, been the result of this fever for governmental control which has spread of late so rapidly and widely over our country. Sometimes this has been due to ignorance, sometimes to a desire to misrepresent and mislead, and sometimes to both ignorance and a desire to misrepresent and mislead. I quite appreciate that this last is a serious charge to make and I therefore regret to say that I make the charge advisedly.

The first case I shall cite was undoubtedly one due to ignorance, for a friend of mine, competent and fearless, serving on the same body with the man at fault, assured me of this man's desire to be fair.

While testifying before a certain Legislative Committee, I was asked the following question by a member of this Committee: If 10 per cent. can be earned selling gas at $1.00 a thousand, does it not follow necessarily that 6 per cent. can be earned by selling gas at 60 cents a thousand? It might well be supposed that the question was asked hastily and without thought, but the question was pressed and I was accused by the questioner of quibbling when I replied in the negative. After adjournment, while informally talking matters over with a few of the Committee, this questioner being one of the number present, I was unable to make him see that his question was absurd, and that it could be answered affirmatively only if the gas cost nothing and so the selling price were all profit. And still this man had a vote on a matter of the gravest importance, involving the protection of the legitimate investment of millions of dollars. He was one of the three members of the Committee chiefly quoted in the reports appearing each day in the press. Another member of this Committee, one of the three just referred to, made a written request that the Company whose affairs were under investigation, furnish the Committee with a statement covering a number of years, showing the *cash* profit for each year, the amounts paid in dividends and a detailed account of what was done with the surplus *cash* remaining each year after the pay-

ment of the dividends. It was apparent that this questioner was of the opinion that profit must be represented by cash on hand and that he expected to find undivided profits represented by a corresponding increase in the bank account.

In this same hearing the term surplus was found to be a bone of contention. Many of the witnesses against the corporation under investigation, as well as certain members of the Committee, insisted that surplus meant cash on hand held ready for an extra cash dividend to the stockholders as soon as an opportunity could be found to make such a distribution without attracting unfavorable comment. Suggestions were not infrequently made that certain proposed betterments and extensions for which additional capital was required, should and could be made from this mythical cash surplus. When it was shown that this surplus had already been invested in works and main extensions, this explanation was regarded with suspicion. I suggested that it would be difficult to pay for the main extensions of this year with the surplus invested in the main extensions of the previous years, and that there would be no real gain in converting into cash the latter investments to meet present demands. I was evidently talking to some of the members of the Committee in an unknown tongue.

In this investigation we also were faced constantly with a difficulty which all public service corporations are forced to meet when under investigation as to rates of charge. I refer to the fact that all surplus is regarded as money taken from the consumer through excessive rates of charge irrespective of the consideration to be given to the rates of dividends paid in the past and to the quality of service and management and the right which a well governed concern should have to enjoy, in part at least, the fruits of highly efficient and economical management. For instance I have at times been able to point out that the surplus under examination resulted not from excessive earnings secured by high rates of charge but from the character of design, construction and management of the property far above the average as to efficiency and economy.

and the conservative policy of declaring small dividends during the early years of development and so meeting part of the demands for additional capital for extensions from these undivided earnings. It seems strange that it should be questioned by practical men—but perhaps we no longer are practical as a nation?—that some margin between dividends and earnings should go into the building up of the company's fixed assets. Anything short of this would be considered by the prudent investor and by the Public while investigating for investment as reckless and indicating unsafe management: but in connection with investigations as to rates of charge, such building up of surplus through undivided earnings is regarded with suspicion. Many companies under Commission control have placed themselves in an uncomfortable position as to this question of surplus by failing to represent from time to time such net surplus earnings by the issue of additional securities. Too often commissioners and committee men fail to recognize the difference between watered securities and securities issued against fully proved surplus. Many investigators refuse to admit that the rate of charge should be based upon total property value, irrespective of the face value of securities: though they are prompt to claim that the face value of securities includes water if this value cannot be found in the tangible assets alone.

In the case of a private corporation engaged in an ordinary competitive business, especially in a close corporation composed of few stockholders, it may be justifiable to show plant account at a nominal amount when the actual value is to be reckoned in hundreds of thousands of dollars, but it certainly is not wise nor honest to the stockholders to follow this course in the management of a public service corporation subject to governmental control. In the latter case the books should show the facts at all times as nearly as ascertainable, the assets being shown neither deflated nor inflated. I am not at this time raising any question as to intangible assets, though I hold that it is nothing short of ridiculous to give a dead plant the same value

as a live plant of the same physical character, serving a business of large proportions and healthy character. But this is what the case resolves itself into if only physical assets are valued without regard to their comparative efficiencies and economies in service.

And one cause of difficulty in this connection is to be found in the fact that some companies have been in the habit of confusing reserves for depreciation and other accruing or contingent losses with surplus. A reserve correctly estimated to the best of our knowledge to meet depreciation is in no sense a surplus. It is a liability to the company as a whole, not a liability to the individual owners. No portion of such reserves should be considered or treated as surplus until conditions have developed to demonstrate that the accruing liability has been overestimated.

Depreciation affords endless opportunity for misinformation and misleading statements. The subject is a difficult one at the best and should therefore be treated frankly and with an intelligent appreciation of its inherent difficulties. It should be recognized at once as a difficult subject to adjust on the books of account. Our public service commissions have not infrequently demonstrated their inability to handle the subject advisedly.

One of many sources of error is often apparent in the hearings referred to. Suppose the witness opposed to the company is making an appraisal of plant. He makes his appraisal say, on the basis of reconstruction at present prices and under present conditions. Then he quotes some authority, real or otherwise, as to the life of a certain character of property, (an absurdity in itself), and without taking into account the local controlling conditions, applies that life to the case in hand to determine the deduction to be made for depreciation. I have found commissioners and their employes falling into this error. In a case in which I was deeply involved the opposing expert representing the city, quoted my testimony in a well known case as claiming that the life of gas plants *in*

general was forty years; which of course, I never had thought, believed or said. Using me as his authority he assumed the average life of the plant under investigation as forty years and then claimed that the average age of the plant was twenty years and so had been exhausted to the extent of half of its life, and on this basis he deducted for accrued depreciation. This is plausible to the uninformed (commissioner or layman) but is absolutely without warrant in common sense. In the case referred to, unknown to this witness, for he had made little effort to learn the facts, the plant had been largely rebuilt only a few years before and so the whole assumption as to the age of this plant was vitiated. And this serves to show why such a line of reasoning is faulty of necessity. If we make an *estimate* of accruing depreciation to *guide us as to the future* we do so on certain established and certain other conditions assumed. We ascertain the present condition of the plant and assume what is to be paid for out of current income to keep the plant in effective operating condition. We do not know as to the future nor is it likely that we can control the future for the whole period covered by the estimate; certainly not if the management passes out of our hands. We assume what renewals will be paid for from current income as direct charges to current P. and L. accounts and what renewals shall be charged later against depreciation reserve. To apply the fallacious method referred to it would be necessary to analyze in detail the operations of each of the preceding years to determine if the plant *had been operated and the books kept absolutely in accordance with the conditions involved in the depreciation estimate.* This is out of the question and in such a case would be entirely unnecessary and senseless. We make an estimate of what we believe will be the accruing depreciation due to physical decay, obsolescence and inadequacy because that is the best we can do looking into the future. But when we have the present facts spread out before us there can be no warrant for depending upon a prophetic estimate made years before. This is well exemplified in the practice which should govern in all cases of esti-

mated depreciation; namely, year by year the estimate should be checked up, and corrected if need be, from a consideration of the actual facts as developed in operation. The blind following of a depreciation estimate, especially a general estimate, is folly or worse.

But when we have an appraisal to make, the facts are in a great measure ascertainable by inspection of the visible plant; and even in the case of underground structures, the facts are in a great measure ascertainable by isolated examinations and investigation of operating methods. Then why go to an estimate made twenty years ago when we have the facts at our hands? Especially why depend upon an estimate made for another plant, different in character, built and operated under different conditions and with book values made up under an entirely different system of accounting? If we were asked the cost of a certain completed installation of complicated character would we go to the original estimate of cost or to the books of account which show the actual expenditure?

Before leaving the subject of depreciation I wish to have it understood that I do not admit that *any* deduction for depreciation should be made in the appraisal of plant in connection with investigations bearing upon rates of charge, provided the plant has been so maintained as to give high class service to the public—but this is too large a subject to discuss in this paper.

I am reminded of an interview I had with the President and a Professor of Economics of one of the most prominent and influential universities in the country, an institution which has definitely influenced the legislation (reform, so-called) of the State in which it is located. I was testifying for a certain company before the state commission and the case largely hung on the question of depreciation. Some testimony on depreciation, remarkable for its freedom from common sense, had been given by the engineer of the commission, also a professor of this university. I was asked to meet at lunch the two gentlemen first referred to. Against my desire, for I wanted to get a respite from "shop" talk, the conversation

drifted into a discussion of depreciation. The President of the university took firm ground on the proposition that practically every public service corporation in the country was loaded down with "water," that all plant and construction accounts were inflated and that no companies were really providing for depreciation from income. He evidently doubted the accuracy of the statements I made in opposition to his statement as applying to the majority of our gas companies. Here, as I said, I was in many cases able to speak from the facts within my knowledge and would have to insist upon my statements being accepted as opposed to the hearsay evidence too readily accepted by college theorists.

The Professor of Economics—well known for his pronounced views and reckless statements—was talking at the other side of the table and so failed to hear a question addressed to me by the President. The question was—"You surely do not claim that income set aside to meet accruing depreciation can be expended for renewals?" I replied—"Certainly I do, provided the bookkeeping methods and the basis of estimate on accruing depreciation are in complete accord." The professor, not having heard the question and reply, then asked—" You surely do not claim that income set aside to meet accruing depreciation can be expended for extensions of plant or for new plant?" Again I replied in the affirmative and then added—"The problem is to take out of income a sufficient sum to keep our assets at par and to spread this burden of cost uniformly over the periods benefited, taking care that money spent for renewals and up-keep shall not be covered by additional securities issued." As they disagreed with me without appreciating as yet that they disagreed with each other, I drew attention to this disagreement between themselves and suggested that as two men of theory representing a university of influence, and leading, it would be well for them to compose their differences so that the teachings of the several departments of the university might not be found to be in conflict. Here we have representatives of the type who are influencing legislation and teaching the young men of the

country and who are claiming that the future of the country is only to be safeguarded by the college men. Then, as I have said before in public, God save the country from such saviours.

This reminds me of another experience. I was invited to deliver a lecture before the postgraduate students of a certain university of world-wide reputation. The subject was the relation of engineering to business administration. A certain member of the faculty, Professor of some branch of Economics and a most courteous gentleman, was delegated to meet me and escort me to the university. On the way he commenced to discuss an important gas rate case in which I had been engaged for many months and with which I was thoroughly familiar as to the facts disclosed by the books and testimony. This professor did not know of my connection with the case and so launched out in a most unfettered denunciation of the company's position. It was his privilege to disagree with the company's representatives as to the claims made but not on the statement of facts he presented, which statement was faulty from beginning to end. Finally I asked him where he obtained the figures upon which he based his arguments and he replied, from the newspaper reports of the trial. The reports to which he referred were not only incomplete but they were grossly misleading. I then told him of my connection with the case and showed in considerable detail wherein the data he relied upon was at fault. He then acknowledged that if the newspaper reports were incorrect his position was not warranted. I then asked him if he was in the habit of lecturing to students of the university on current economic topics on the authority of the newspaper reports, these reports frequently prepared by reporters absolutely incompetent to analyze a balance sheet or to comprehend the technical features of the testimony. He acknowledged that such was his practice though he tried as far as possible to verify his data before accepting for lecture purposes.

And so are many of our young men misdirected in connection with the so-called higher education. If this were the best

that could be done for them in these institutions, it were better to send them out into the field of work to learn by hard experience. It is greatly to be regretted, and particularly so at this time of unrest, that so many of our professors of economics are theorists only and have apparently no appreciation for the controlling influence of the practical conditions necessarily involved in the application of their theories. If they investigate, therefore, they do so without getting below the surface. Too often their investigations are unscientific from the start because the effort is to prove a proposition already accepted rather than to hold the mind open for the reception of all available truth. They are trying to bolster up an accepted theory rather than to develop through investigation and research a correct and complete theory. Whether these men are in the majority or whether they press forward into public view more than the better qualified students of economics, I am unable to say. But let that be as it may, we may well be thankful for the services rendered to the country by the professors and other students of economics who are honest, capable and sane.

I am not decrying higher education, but I am entering an earnest protest against much that is taught in our universities and colleges by men of books, who find an easy way to attract attention by assailing established institutions; especially I protest at the incompetence and prejudice often displayed by professors of economics. I prophesy that those responsible for the management of some of these institutions of higher learning will yet find cause to regret the freedom accorded to these apostles of socialism and anarchy. But it is probable that before the final result of this kind of "Higher Learning" is experienced, some of those responsible for permitting these men to occupy their chairs, will be comfortably buried and so escape any participation in the sad outcome of this loose and foolish interpretation of the right of professors to unrestricted freedom of speech. Suppose a professor of physics chose to teach perpetual motion, should such freedom of speech go unchecked?

The last case to which I shall refer furnishes a striking illustration of failure on the part of a certain Commission, or its subordinates, to correctly present operating results in its published statements. In the early part of this year, the sales, gross earnings, operating expenses, profits, etc., of a large company within the jurisdiction of the Commission, were given out for publication in tabulated form by the Commission's chief statistician. These statements grossly misrepresented the affairs of the Company in question, and were apparently designed to convey an impression of an immense increase in profits in the face of a material reduction in price. The volume of sales was not only over-stated nearly 14 per cent., but the gross earnings were proportionately inaccurate and furthermore included receipts entirely inapplicable to the proposition under discussion. From the expenses were omitted such items as taxes and uncollectible bills, and in the profits were included inter-company dividends to the extent of several hundred thousand dollars, involving duplication of profits to this extent. The result of this distortion of the facts amounted to an over-statement of the Company's net revenue to the extent of 55 per cent. of the correct amount. The fact that millions of dollars of bonds had been converted into capital stock, thus enormously increasing the net profits as found after deduction of fixed charges, was entirely ignored. The comparison between gross profits applicable to bond interest and dividends was significantly omitted. From every point of view, the statement was utterly worthless—whether from that of the investor, the stockholder, the statistician or the student of economic or civic questions. The only conclusions which could be drawn from it would be necessarily false and misleading. It amounted in brief to a gratuitous exaggeration of the Company's prosperity, which could only be attributed to a deliberate design to deceive and mislead the public or to culpable negligence or gross ignorance.

Public Service Commissioners cannot escape responsibility for the acts of their subordinates in publishing information gathered from the reports of the Companies within their jur-

isdiction, when such statements are compiled so as to be misleading. In their desire to magnify their importance or for political or other purposes, certain of the Statisticians, Accountants and Experts connected with these Commissions are too eager to issue statements in the name of the Commission, which are not only inaccurate, but designed to be sensational. They often serve only to inflame and prejudice the public mind with respect to the corporations. Such voluntary contributions on the part of the Commissions' subordinates are certainly no part of their function, as outlined in the Public Service Commission Laws, and should not be tolerated by the Commissioners, the Public or the Corporations. Such misleading statements from the hands of subordinates should call for prompt and frank corrections from the Commissioners and the disciplining of the guilty subordinates. These subordinates are employed and paid by the Commission and are presumably subject to its control. For them to be permitted, unchecked by the Commission, to give free expression to their personal hostility, however inspired, towards the Companies, employing for that purpose, in garbled and distorted form, the facts and figures which the Companies are compelled by law to place at their disposal, is a monstrous perversion of the spirit and intent of the Public Service Commission acts.

If the Commissions and others in authority are really desirous of improving conditions, then every possible care should be taken that all statements given to the press for the information of the public are as nearly correct as the trained human intelligence can make them. Certainly if statements are to be made to the public based upon analysis of data open to question, the representatives of the corporations should at least have the right to discuss these statements with the government officials in advance of publication.

It should be remembered that these statements are not only for the public in general, but they are particularly studied by investors, those interested in civic questions, and the student of economics. All of these and even the reformer, if honest, are entitled to true and intelligent statements. Cer-

tainly the investor should not be lead astray by such grossly misleading statements as the one I have just discussed.

Brokers and others wishing to influence the prices of securities should not be furnished with weapons by the authorities charged with the duty of acting between corporations and the public for the protection of both.

Let me particularly refer to one detail in financial statements which leads often to confusion or worse. I have in mind the different meanings attached to terms of accountancy —earnings, income, net income, profits, net profits, surplus, etc. Where an amount is stated as profit there should be no question as to what is intended. It should be shown clearly whether the amount named is the total profit applicable to the payment of interest on bonds and dividends and the building up of surplus, or whether it is net profit remaining after providing for fixed charges. If comparisons between years or with other companies are to be made, the comparisons should be made on the same lines and it should be shown by the statement exactly *what is the basis of comparison.*

In short, there should be, on the part of the Commissions particularly, a desire evidenced to educate the public rather than to mislead them, and this should be done through the medium of carefully prepared public documents, not through hastily prepared special briefs aimed at the corporations coming under their supervision.

I for one cannot believe that we who are responsible to our stockholders for the conduct of public service corporations have the right to submit to misrepresentation, even when that misrepresentation comes from a Commission which has been given a power of supervision and control over us, and though in the hands of unscrupulous and vindictive men this power may be exercised against us later by way of retaliation.

The President: I think a vote of thanks should be given to Dr. Humphreys for his paper.

A motion to that effect was duly carried.

THE PRESIDENT: We have now a paper on

CONTINUOUS CARBONIZATION IN VERTICAL RETORTS.

BY MR. J. S. DEHART, JR.

Mr. DeHart then read his papers as follows:

CONTINUOUS CARBONIZATION IN VERTICAL RETORTS.

This paper covers a short description of an experimental bench of vertical retorts of the Woodall-Duckham system of continuous carbonization at the La Grange Station of the Western United Gas & Electric Company, Aurora, Illinois. It was built practically on the plans of the experimental bench at the Nine Elms Station of the Gas Light & Coke Company, London, England, with the idea of studying the working of American coals in American retorts.

The bench consists of four retorts 25 ft. long, oval in section, 9 in. by 21 in. at the top, 20 in. by 29 in. at the bottom, heated by a producer with twin grates and twin charging holes, all supported on steel platform 10 ft. above grade. The upper mouthpieces are fitted with separate feeding drums, each operated at a speed to keep the retorts full of coal. The lower mouthpieces of each retort are fitted with a coke extractor and revolving drum. The speed of the coke extractor controls the carbonization in each retort. The coal feeding drums make three-quarters of a revolution a minute, the coke extractors make three-quarters of a revolution an hour and the drums discharge four times an hour.

The bench is located at one end of the retort house and is run in connection with horizontal benches, or alone as the gas supply will allow. Retort house governors control the pressure for each system. Coal is passed through a small crusher and raised by an elevator to a twenty-four hour storage bin above the retorts. The coke is taken away from the bench in wheel-barrows. A small vertical engine runs the coal feeding drums and extractors.

The heating of the bench is very simple. All the producer

gas goes directly to the top of the combustion chambers where it is distributed by four dampers. The furnaces have angle iron grate bars and step grates for the supply of water but in addition to the above steam is used and measured by discs and regulating valve. The furnaces are cleaned once each forty-eight hours and are practically free from clinkers. Secondary air passes through a recuperator in the back wall of the bench across the bottom and is distributed to the top and middle of the combustion chambers by four dampers. When the proper distribution is obtained the main stack damper controls the heats.

All the fire brick material, with the exception of three retorts, was made in this country. The three retorts are machine made and imported from England.

The bench was completed about September 1, 1909, and was operated until February 1, 1910, the greater part of the time in conjunction with the old benches. The bench was not protected from the weather until late in the Winter and the coal available was taken directly from the cars in a more or less unsatisfactory condition at times. In November it was possible to shut down the horizontal benches for ten days, during which time the following average results were obtained from Youghiogheny coal.

Coal used	20,151
Coke made	14,841
Gas made	108,637
Generator fuel	3,598
Yield gas per lb. coal	5.39
Coke yield per cent. coal	73.6
Generator fuel per 100 lbs. coal	17.89
Generator fuel per cent. coke made	24.30
Candle-power on Suggs Argand D.	14.47
B. t. u's gross	609
Candle feet	77.91

The data is not as complete as we would like to have it but it may be of interest to your members. It was impossible to

maintain proper temperature conditions in the foul main and condensing apparatus and the gas passed through a relief holder in going from the condensing apparatus to the purifiers. Dew points were not taken at the works during this test so that the candle-power corrections are for 60° only. While these results were fairly satisfactory, taking into consideration the conditions under which the plant was run, the top labor and the leaky drums were a constant source of trouble for uniform operation. The horizontals were again shut down in January, 1910, for ten days, during which time we experimented with the heating of the bench as much as this design would permit with the idea of eliminating the bridging at the top, so that no reliable data was taken at this time except to get a general line on the tar and ammonia in the gas. This would indicate that we can safely anticipate 7 lbs. of ammonia and 14½ gal. of tar per ton of coal carbonized.

After shutting down the bench in February, it was decided to remove the revolving drums and substitute cast iron hoppers and balanced self-sealing doors. The bench was again started in August, 1910, with the hope that it would be possible to shut down the horizontal benches for a considerable time. It has been impossible to do this, however, so that the vertical bench is now running in conjunction with the horizontals. The hoppers and self-sealing doors are extremely simple to operate and are discharged once an hour, requiring less than one minute, and are absolutely gas tight. At the present writing there is still considerable bridging at the top but changes are under way which it is hoped will practically eliminate this trouble, even with the high volatile Youghiogheny coal. We could undoubtedly eliminate a great deal of trouble of sticking in the top section with a low volatile coal, but up to the present time have devoted all of our attention to the successful carbonization of the high volatile coal such as is more generally used by gas companies.

The President: Are there any gentlemen who would like to discuss this paper by Mr. DeHart? If there is no discussion,

having finished our program for this time, the meeting stands adjourned until 10 o'clock tomorrow morning.

(Adjourned at 5:10 P. M.)

THURSDAY, OCTOBER TWENTIETH.

MORNING SESSION.

The session was called to order at 10:30 A. M.

THE PRESIDENT: I had intended, as the first topic for discussion this morning, to take up the paper of Mr. DeHart. I thought some members might want to speak on that subject. Mr. Ellis, who has lately put in an installation of vertical retorts, asked yesterday to have time to speak to the members on that subject, but as they do not seem either of them to be here, we will postpone that discussion till later. The first paper on the program this morning is

THE LIGHTING AND VENTILATION OF GAS APPLIANCE DISPLAY ROOMS.

BY MR. THOMAS SCOFIELD.

Mr. Scofield then read his paper as follows, illustrating the same with lantern slides.

THE LIGHTING AND VENTILATION OF THE GAS APPLIANCE DISPLAY ROOMS.

There are few buildings at the present time which are entirely devoted to the display and demonstration of gas in all its various uses in all its different fields. Few buildings which can be pointed out for certain installations which have been in operation and in ordinary use, while tests and data have been taken for the benefit of the scientific world as well as the general public. Few buildings which can be shown as completely equipped with the latest appliances, which are in actual test and demonstration the entire time. In these respects the Gas Appliance Display Rooms, at 29 East 21st Street, New York City, are unique and of great interest to the gas world. The building itself is a five-story and basement loft building which has been taken as the main office for the General Fuel Appliance Department of the Consolidated Gas Company of

New York, and for the display and actual demonstration of appliances, not only in the domestic field but in the fields of art and manufacture. (Fig. 1.)

The first two floors and the basement are devoted to the

Fig. 1.

actual display of appliances, the basement containing the large hotel ranges, broilers, steam tables, furnaces, blast appliances for use in the industrial arts, smokehouses, bakers' ovens, a model kitchenette, a model laundry with clothes dryer, (Fig. 2), washer, mangle, and gas iron, hot water heaters,

and in short all appliances of the larger type now on the market, all of which are not only on display but ready for instant and practical demonstration.

Here is also found the gas boiler which furnishes all the

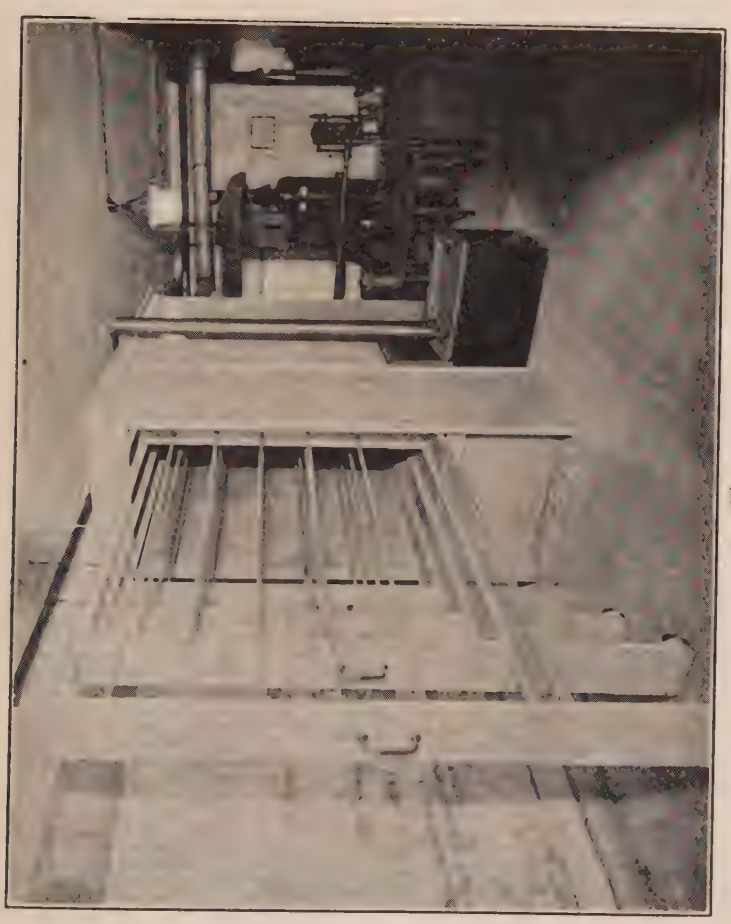


Fig. 2

steam for heating the building. (Fig. 3.) On the first, or store floor, are shown the smaller gas ranges of all styles, the small heaters and radiators, and the many accessories and small appliances which use gas, completely covering the domestic field

The second floor is laid out as a model apartment, consisting of five rooms and bath, and offers a striking example of artistic and scientific illumination with gas as the illuminant.

Fig. 3.

The third, fourth, and fifth floors, are devoted to offices of the General Fuel Appliance, New Business, and Illuminating Engineering Departments. Thus the same building offers a prac-

ideal demonstration of store, window, home, and office lighting combined with the display and demonstration of appliances of all kinds.

The basement is lighted with eight gas arcs or clusters.

Fig. 4

This unit consists of a four mantle inverted cluster with alabaster globe, each unit operated by chain pull. This installation offers an opportunity of seeing what can be done with the gas arc in the way of efficient and economical illumination.

The store floor, (Fig. 4) being used as a place of exhibition of smaller gas ranges and the innumerable small domestic articles whose general tone is dark, or in fact black, had to have

Fig. 5.

a light color scheme. This has been provided by having the walls colored a light cream with the ceiling pure white, the woodwork being also white. In this manner the maximum illumination from the units installed is secured. These units

consist of an 8-light combination electric and gas fixture. They

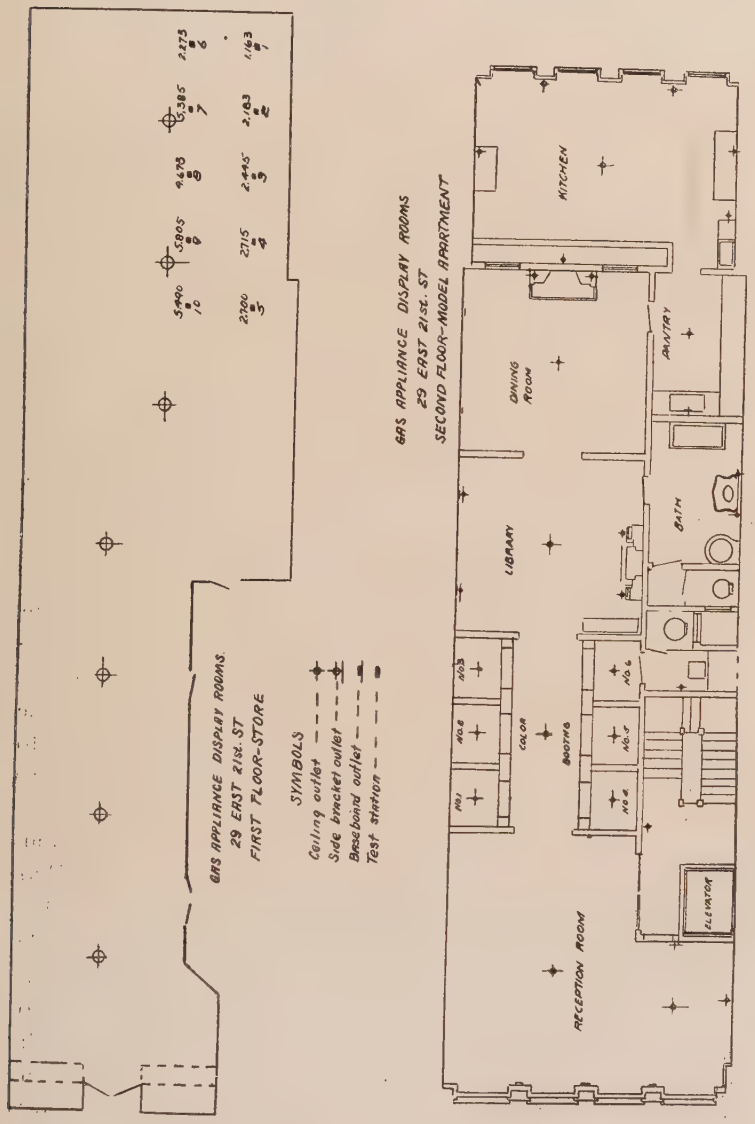


Fig. 6.

are each equipped with four 40-watt frosted tip Tungstens,

and four Reflex burners, with clear inner cylinders, and the glassware for both the gas and electric lights is Holophane satin finish distributing reflectors. (Fig. 5.) The great similarity between the units is clearly shown. They both have practically the same physical contour, both derive their light from an incandescent body, in each case nearly cylindrical in shape, both incandescent bodies are enclosed in a glass bulb, and hung from a frame or bracket, and the same glassware can be applied to each and the same distributions secured. Both units can be lighted or extinguished by the pull of a chain, and when either burns out can be replaced with a new unit. The adjustment to maximum intensity of the new incandescent mantle can be compared to the selection of the correct voltage lamp for the electric circuit, and as far as outward appearance goes, there is so little difference that, unlighted, one can easily be mistaken for the other. As the store is too deep to allow for a satisfactory daylight illumination throughout its whole length, the Reflex burners on the fixtures near its center are used practically all day. The daylight value of the incandescent burner is well brought out here, for the color of the illumination from them is so close to the true daylight that to all appearances the entire store seems to have the same uniform illumination. For the purpose of testing this installation and to determine the mean average value of the illumination, the rear portion of the floor was divided into four equal rectangles. One of these was subdivided into 10 smaller and equal rectangles, and a test station established at the center of each of these. (Fig. 6.) At each of these stations horizontal illumination values were read on a Sharp Millar Photometer, the instrument having been standardized at the Electrical Testing Laboratories before these tests were made. Several readings were taken at each station in order to eliminate as far as possible the personal error in reading the photometer. The average of these readings at each station is the figure recorded in the tables, and the mean of all these averages is assumed to give the average illumination of the area tested. Pressure was measured by a U tube manometer and

readings on the meter, installed for this floor, taken for long enough periods to assure accurate consumption figures. The results follow:—

First Foor.

Observed Horizontal Illumination Values.

Station	Foot-candles	Station	Foot-candles
1	1.163	6	2.273
2	2.183	7	5.385
3	2.445	8	4.673
4	2.715	9	5.805
5	2.700	10	5.490

Maximum dimensions of floor.....91′ 0″ x 23′ 0″
Height to ceiling .....11′ 10″
Height to mantles .....10′ 0″
Height to test plane .....2′ 9″
Height mantles above test plane.....7′ 3″
Number of outlets 7
Number of burners per outlet 4
Total number of burners 28
Distance between outlets .....12′ 0″
Total gas consumption, cu. ft. per hr.....96
Average consumption per burner .....3.43 cu. ft.
Pressure, inches of water 1.7
Total area of floor tested, sq. ft. 1105
Cubic foot gas per square foot, entire floor 0.055
Number of test stations 10
Average foot-candles 3.483
Lumens per sq. ft. of gas 70.13

The curves (Fig. 7.) show graphically the illumination values obtained, and although no attempt at uniformity of illumination was made when the installation was laid out, show but small fluctuations in intensity. No special adjustment of the mantles was made for this test, the installation being in normal working condition, as it has been kept by the regular maintenance system for over a year. (Fig. 8.) The display windows are each lighted by 12 Reflex lights, arranged in two rows of six in each window. These are equipped with satin finish Holophane dis-

tributing reflectors and clear inner cylinders and are controlled

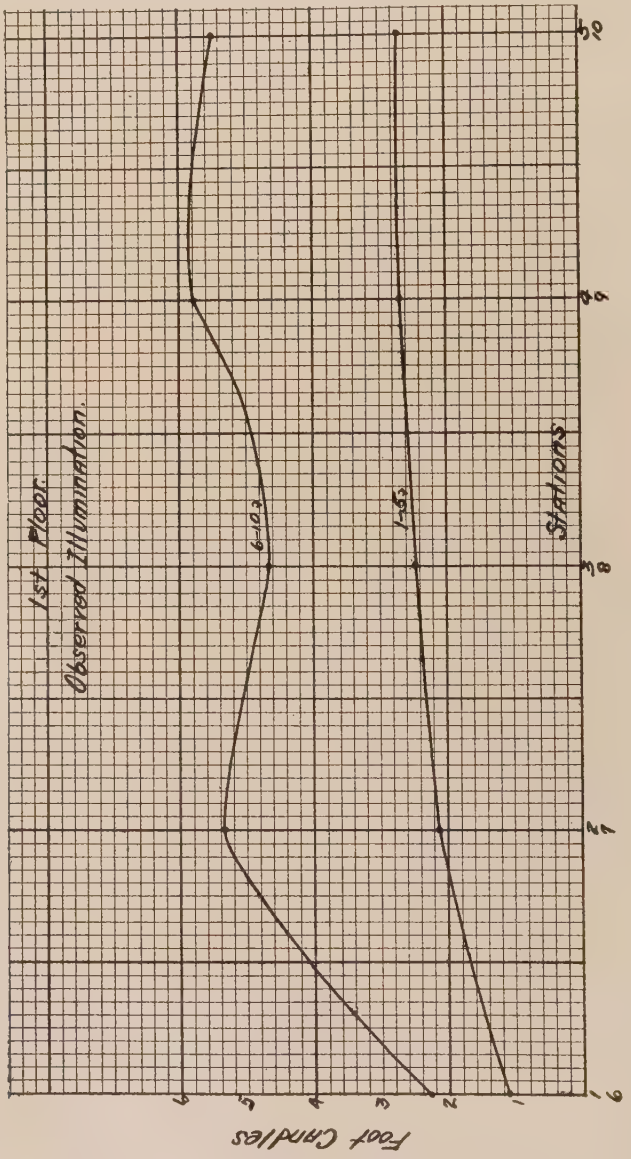


Fig. 7.

on a pneumatic system one pump operating each six lights.

The height from the window floor to ceiling is 10 ft. 3 in., and the height of mantles above floor, 8 ft. 10 in. Horizontal foot-candle readings were taken on the photometer on a plane 6½

Fig. 8.

in. above the floor, giving an average illumination of 29.6 foot-candles.

The second floor is occupied by the model apartment. Here the most modern and improved methods of lighting for the home can be seen, and a splendid idea of what can be done

with gas when treated scientifically and yet artistically can be gained. The front room is a combined reception and business room and is decorated in green, offering a restful and cool place for the demonstrators and visitors to the building. The lighting is taken care of by a central fixture, carrying four Reflex burners with frosted tip inner cylinders, and fancy fluted alabaster shades. A two-light reflexolier and a side bracket similarly equipped, in the alcove, complete the installation, which is not only very efficient with its soft diffused light, but very artistic and in thorough keeping with the room and decorations. (Fig. 9.) One of the most interesting exhibits in the building is located in this reception room. It is the Sochrodometer, an apparatus for demonstrating the different colors the same material can assume when viewed under different illuminants, and at the same time showing its true daylight color. The derivation of this word is perhaps of interest, it having been coined specially for this apparatus. It is derived from solar, relating to the sun; chromatic, referring to color; Osendo, meaning false, and comparimeter, designating comparison, and therefore literally meaning a false comparison of sun colors. The apparatus itself stands on a table at the front of the reception room and near its easterly window. It is made of brush finish copper and stands 3 ft. 6 in. high, by 5 ft. 5 in. long, by 1 ft. 7 in. deep. It is divided into seven compartments through which bands of various colored ribbons travel on an endless belt. Each of these compartments has a different illuminant lighting these ribbons as they pass through the compartment. The machine is so arranged that either end may be placed near a window to give the daylight effect, the other compartments having the incandescent electric, the Tungsten, the electric arc, the flat flame gas burner, the upright Welsbach, and the inverted Welsbach incandescent light respectively. Arrangement is made so that a person having some definite color or material to try, can attach the sample to the belt of ribbons and get the color values under all lighting possibilities, and at the same time a comparison of these values with direct daylight.

Between the reception room and the library is a corridor on either side of which are three booths. These booths are all exactly the same size, that is 5 ft. wide by 4 ft. deep, by 9 ft. 4 in.

Fig. 6.

high from ceiling to floor, and they are used for an occult demonstration of the effect of various colors in decorations and hangings, on the efficiency of the lighting installation. This fact has long been known to the Illuminating Engineering world, but has not been put before the public in a de-

monstrative way before. (Fig. 10.) Each of these five booths, the sixth comprising a cloak room and anteroom, is papered with a different colored wall paper, and the curtains in the door of

Fig. 10.

each are lined with the same color as the walls of the booth. All the papers are of as nearly the same texture and surface as possible, so that the effects shown are dependent principally upon the color alone. For illumination in each booth a single reflex drop is hung from the center of the ceiling, each

equipped with clear inner cylinder and clear Holophane distributing reflector so that the distribution in each booth will be the same. The colors used are as follows:

Booth No. 1 salmon	Booth No. 4 green
Booth No. 2 red	Booth No. 5 blue
Booth No. 3 cream	Booth No. 6 cream.

To test for comparative illumination figures in booths Nos. 1, 2, 3, 4, and 5, all the reflex lights were adjusted so that their mantles were as near the same intensity as possible, and so that they all had the same consumption. A test station in each booth was then taken directly under the light, and illumination readings on the photometer taken on a horizontal plane 3 ft. above the floor, making the height of mantle above the plane 5 ft. 4 in. in each booth. The percentages given below are all based on booth No. 1 as 100 per cent. Several readings were taken at each test station to eliminate as much as possible the personal error in taking observations. The difference in the color of the reflected light was very clearly brought out on the photometer screen,—booth No. 1 more nearly matching the Tungsten standard lamp than any of the others. The results are as follows:—

Booth	Foot-candles observed	Percentage of No. 1
1	6.248	100.00
2	2.105	33.69
3	3.975	63.62
4	3.553	56.86
5	2.510	40.17

Passing through this corridor we come to the library. (Fig. 11.) This room is especially noteworthy for the artistic blending of fixtures and decorations and the efficiency and perfect diffusion of the light. The room itself is wainscoted in English oak, with furnishings of the same material and the general decorative scheme is carried out in dark reds and golden browns The mantel is an impressive and beautiful piece of work, being designed and executed especially for this room. The spé-

cial lighting for reading is done by a central dome over the large library table. This dome is of hammered copper and amber glass and is equipped with a single reflex burner with

Fig. 11.

Holophane distributing reflector. The light which the reflector allows to pass through the amber glass, for decorative purposes, harmonizes perfectly with the decorations and furnishings of the room, and still the reflector directs most of the light directly downward, where it is of the most use. In

order to properly diffuse the light thus directed, and prevent all glare from reaching persons seated around the table, the bottom of the dome has been covered by a plate of ground glass, allowing sufficient light to pass through for reading, and yet softening it for the eyes. The general or decorative lighting of the room is taken care of by two standards on the mantle, also of hammered copper and amber glass, equipped with small upright incandescent burners; by two side brackets with Bijou inverted burners; by a portable table lamp, with standard upright incandescent burner, and by a portable book-case lamp, with a Bijou inverted burner; all in copper and amber glass, and combined, giving a soft diffused light bringing out the decorations with great effect. The chief points of interest in this library, and ones which strike one at once on entering, are the efficient illumination, the total absence of glare, and the harmony of fixtures and decorations, a thing seen too seldom.

Directly off the library is the bath-room, (Fig. 12.) done in white tile with nickel fittings. The illumination is furnished from two side brackets, also nickel, placed one on either side of the mirror and directly over the wash basin. These brackets are equipped with Welsbach Junior burners, and Holophane No. 2404 diffusing globes. These give an efficient and well diffused light, and are a good example of the correct positions of the lighting fixtures in bath-rooms and dressing rooms.

Back of the library is the dining room, (Fig. 13.), finished in old Colonial style with blue on the walls, white woodwork, and fitting mahogany furniture. This room again is a good example of how the illumination can be efficient and at the same time the lighting fixtures in keeping with the decorations. In order to carry out the true Colonial idea, a time when the lighting was done entirely by lamps and candles, the two side brackets directly over the mantle, are fashioned as lamps, hung with crystal prisms. They are equipped with upright Welsbach burners, and serve as a means of general illumination for the room. Over the dining table is a large dome, in its outline and fringe of crystal prisms again suggesting the lamp period. This dome has four small upright Welsbachs, and, like the

done in the library, carries a bottom plate of ground glass, in this way removing all chance of the intensely brilliant light sources coming into direct line of vision of anyone seated at any point around the table. On either side of the fireplace and

Fig. 12.

mantle, which one faces as they enter the room from the library, a window has been built in the false partition. Outside these windows, the visitor sees a trellis covered with climbing roses, apparently glowing in full sunlight. This effect is produced by having large upright Welsbachs inside the

false partition, directly behind the mantle, which reflect their light from the mat white surface of the walls of the partition, and in this way give the sunlight effect. The result is start-

Fig. 13.

ling in its realism, and brings out with great force the true daylight value of the incandescent gas burner.

Adjoining the dining room is the butler's pantry, (Fig. 14.) complete in all details. The lighting here is worthy of notice for in many modern buildings, private houses and apartments, the

correct lighting of the pantry seems to have been neglected. The general lighting is from a central fixture, with its upright Welsbach, with opal dome and Bobesche, providing all the light

Fig. 14.

necessary for the china closets, linen chests, and shelves. Over the sink a side bracket carries a Ramsdell inverted Bijou burner, which insures ample light and which overcomes the very

common fault so often found, of the necessity of working in one's own shadow. From the pantry, we go to the last room of the apartment, the kitchen. (Fig. 15.) Like the pantry,

Fig 15.

it is completely equipped with all the accessories needed in the culinary art, and also like the pantry, it shows the correct method of illumination. It seems to be the usual tendency to spend most of the thought and time on the lighting of the other rooms of a house, and the kitchen

seems to be left to its own devices, a central, one-light fixture generally being provided for all the work. For the general lighting of this room there is a central 2-light reflexolier, with Holophane clear distributing reflectors, and the special illumination is taken care of in the following manner: Under the hood of each of the ranges here installed, is a swinging wall bracket, carrying a reflex light with white porcelain cone reflector. These brackets can be moved around at will, directing their light on any portion of the stove top where a cooking operation is under way. Over the tables and the sink are side brackets, with the same equipment, making it possible to work in any part of the room without having one's shadow cast over the work. Aside from the bad effects on the eyes, of anyone working in a poorly illuminated kitchen, all our food is prepared in this room, which we endeavor to keep as clean and sanitary as possible. Therefore, does not a deficiency of light defeat the very result for which we are striving?

The third floor is occupied by the offices of the General Fuel Appliance Department and offers an illustration of modern office lighting. A few years ago the approved method of office lighting was by individual lights on each desk, with perhaps some general illumination. Shortly after the Tungsten unit was developed by the electric interests, they evolved a system of uniform illumination from evenly distributed small units or sources of light. This proved a success, supplanting the individual desk lights and reducing the severe eye strain so often developed through poor adjustment of the same. They called this the "distributed unit system." On the third floor of this building is installed and in operation the first distributed unit system, using gas as the illuminant. (Fig. 16.) As the building was not piped for any such conditions, and as ripping out the ceiling for the purpose of running the piping, was not only inconvenient, but would have constituted a great handicap for the installation of like systems in buildings already in use, a method was devised for using the old outlets in the ceiling. The pipe was run, as required, along the ceiling and

then covered over with a decorative moulding, matching the cornice of the ceiling. This gave the ceiling a paneled effect, very pleasing to the eye as a decorative addition. A section of the

Fig. 16.

moulding is shown with its main central groove for the pipe, and its two smaller side channels for either electric wires or pneumatic tubes, depending entirely on the system of ignition used. Twenty-six outlets were left on this floor, each one having a single reflex pendant, with clear inner cylinder and satin finish

Holophane distributing reflector. The lights are controlled on a pneumatic system, each button on the wall taking two lights,

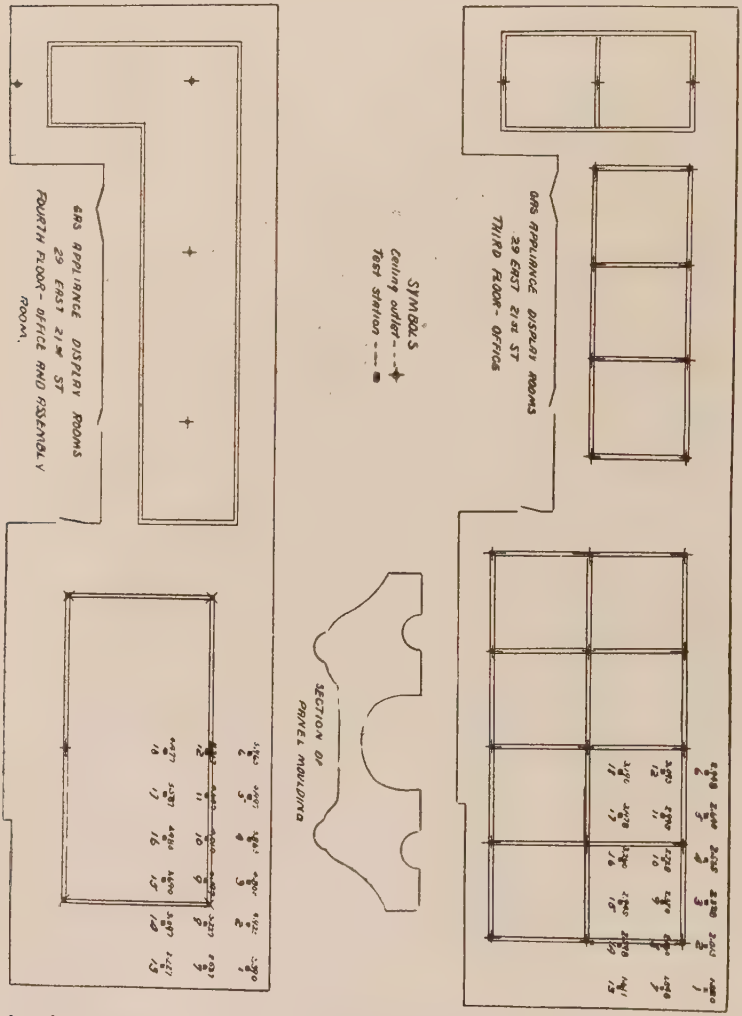


Fig. 17.

in the front of the floor, and three at the rear, with the three lights in the extreme front bay controlled separately. The installation has been in constant operation for over a year and the bookkeepers, most of whom work under the artificial light

continually, have found it very efficient. The rear portion of this floor was divided into four equal rectangles, one of which was again sub-divided into 18 smaller and equal rectangles, at the center of each of which a test station was established. (Fig. 17.) No adjustmentwas made of the system excepting that due to the regular maintenance. Horizontal readings of illumination were taken at each station, several readings being used at each to avoid as far as possible the personal error, and the average of all the 18 stations was taken as the average illumination of the room. Pressure and consumption were also read, as on the first floor. The results follow:

THIRD FLOOR.

OBSERVED HORIZONTAL ILLUMINATION VALUES.

Station line 1-6	Foot-candles	Station line 7-12	Foot-candles	Station line 13-18	Foot-candles
1	1.220	7	1.548	13	1.611
2	2.013	8	2.160	14	2.598
3	2.328	9	2.370	15	2.945
4	2.525	10	2.728	16	3.260
5	2.640	11	2.995	17	3.478
6	2.948	12	3.093	18	3.190

Maximum dimensions of the floor .....84′ 0″ x 22′ 0″
Height to ceiling .....10′ 0″
Height to mantles .....8′ 10″
Height to test plane .....2′ 9″
Height of mantles above test plane .....6′ 1″
Number of outlets 26
Number of burners per outlet 1
Total number of burners 26
Distance between outlets ..... 8′
Total gas consumption cubic foot per hour 83.2
Average consumption per burner 3.2
Pressure inches of water 1.8
Total area of floor, square feet 1680
Cubic foot of gas per sq. ft. of floor.....0.049
Number of test stations 18
Average foot-candles 2.536
Lumens per cu. ft. of gas 51.207

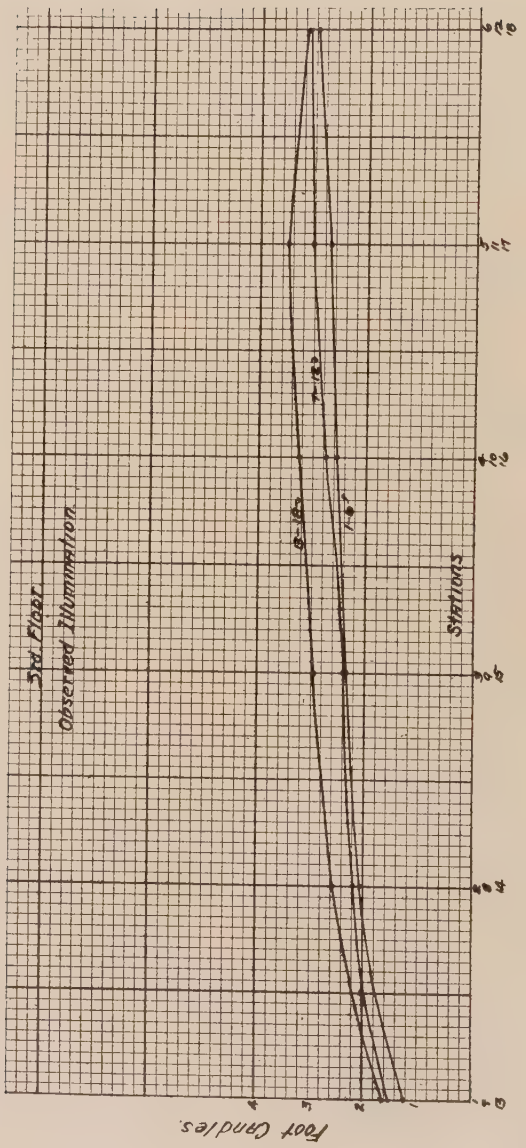


Fig. 18.

The curves (Fig. 19.) show graphically the observed illumination, and also bring out the great uniformity obtained, the greatest divergence between the mean illumination and any

Fig 19

of the 18 stations being only 51.89 per cent., and this occurring at station No.1, at the extreme corner of the room.

The fourth floor, (Fig. 19.) also an office floor, used for the canvassers as a general meeting place and for general offices,

is lighted by nine 4-light reflexoliers, equipped with clear inner cylinders and Verre Krasna globes and each controlled by a single button on the pneumatic system. Here no attempt has been made for uniformity of illumination, as the curves of the observed illumination show. The same corresponding test stations were established as used on the floor below, and the test carried out in a similar manner with the following results:—

FOURTH FLOOR.

OBSERVED HORIZONTAL ILLUMINATION VALUES.

Station line 1-6	Foot-candles	Station line 7-12	Foot-candles	Station line 13-18	Foot-candles
1	2.390	7	2.537	13	2.227
2	3.923	8	5.227	14	3.097
3	4.803	9	6.197	15	3.640
4	3.863	10	4.017	16	3.483
5	4.497	11	4.647	17	3.587
6	5.963	12	8.717	18	4.477

Maximum dimensions of floor ..... 84′ 0″ x 22′ 0″
Height of ceiling ..... 10′ 0″
Height to mantles ..... 8′
Height to test plane ..... 2′ 9″
Height of mantles above test plane ..... 5′ 3″
Number of outlets 9
Number of burners per outlet 4
Total number of burners 36
Total gas consumption, cubic foot per hr. 115
Average consumption per burner 3.194
Pressure inches of water 2.0
Total area of floor, square feet 1680
Cubic foot of gas per sq. ft. of floor 0.068
Number of test stations 18
Average foot-candles 4.294
Lumens per cubic foot of gas 63.73

The greatest deviation from the mean on this floor occurs at Station No. 12, where we have 8.717 foot-candles, or a difference of 103 per cent. as against 51.89 per cent. on the third floor. (Fig. 20.)

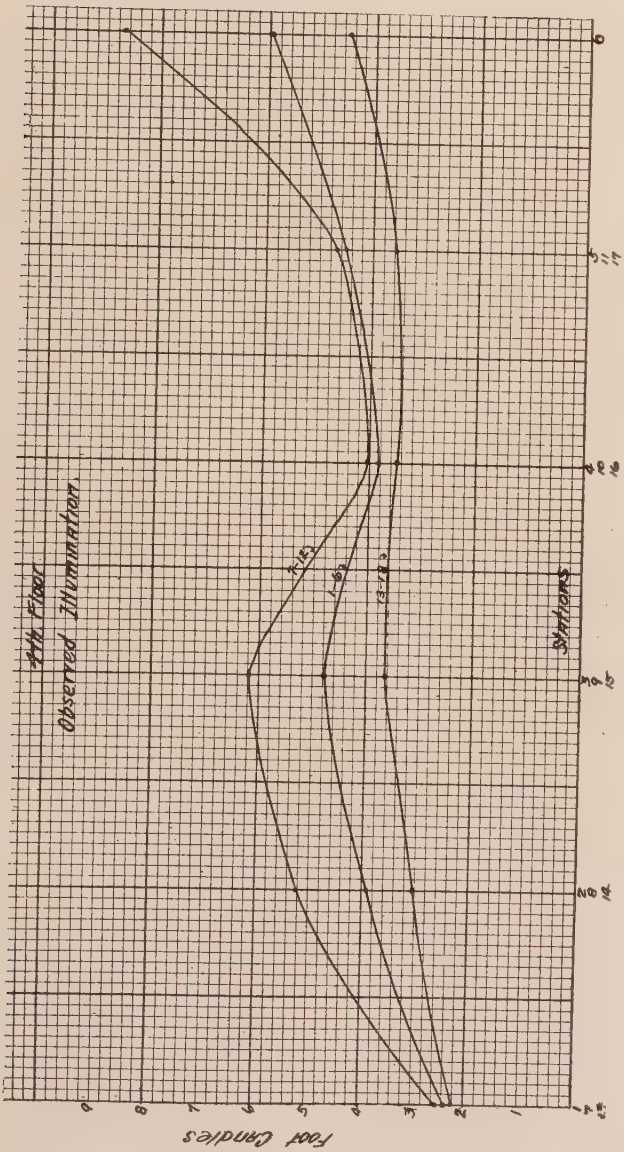


Fig. 20.

The fifth floor of the building is devoted to general offices of the Fuel Appliance, New Business and Illuminating Engineering Departments, and to experimental lighting appartus.

The necessity of ventilation for the apartment on the second floor was very great, for here the rooms, being laid out on an ordinary loft floor, had no direct communication with the outside air, excepting in the case of the extreme front and rear rooms. Again, as all the floors are of considerable size, and the office force large, good, clean, pure air was essential for the comfort and health of all working in the building. Two ventilating systems therefore have been installed, one which takes care of the basement and the appliances, the appliances in the store, and the two ranges in the kitchen of the apartment on the second floor, and the other which takes care of the second, third and fourth floors. The fifth floor, having direct ventilating facilities by means of skylights to the roof, has had no artificial ventilation provided for.

The system for the basement is laid out as follows:

A 10-inch galvanized iron round duct is run along the west wall near the ceiling and across the rear wall to the easterly window, where it joins another similar 10-inch duct, running the length of the east wall. These ducts have 6 in. diameter, openings, spaced approximately every seven feet of their run, making a total of 18 of these openings. Each of these is provided with a damper so that whether being used as a flue for an appliance or for general ventilation of the room, they can be regulated at will. In addition to these 18-6 in. openings, three registers, 6 in. by 12 in., have been left in the 10-inch ducts for general ventilation, and these are also fitted with dampers. The two 10-inch ducts join at the easterly window, and form a 14-inch round duct which rises to the roof. Into this 14-inch riser runs a 6 in. by 6 in. connection which provides ventilation for the appliances in the store, and an 8½ in. diameter connection, which takes the two 6 in. diameter ducts from the ranges in the apartment kitchen. This riser terminates about 15 ft. above the roof in a revolving ventilating cap, natural draft being used for this system. However, in case

mechanical draft should become necessary, this riser has a by-pass, on the roof, in which is located a motor driven fan. In order to prevent the fan from simply drawing air through the ventilating cap and down and out through the by-pass, an automatic system of valve regulation in the riser and by-pass was devised. A governor on the shaft of the fan operates, through a system of levers, a butterfly valve, placed at the point where the by-pass joins the riser. This valve at one extreme position shuts off the riser just above the by-pass and at the other extreme position shuts off the by-pass at its intersection with the riser, leaving the latter open. Whenever the fan is started then, this valve closes the riser, insuring all the air, being exhausted, passing through the fan only, and when the fan is stopped the valve closes the by-pass, and the ventilation is done via the ventilating cap. The fan is an 18-inch disc fan and has a capacity of 1,200 cu. ft. per minute.

For ventilation on the second, third and fourth, floors, a motor driven fan was installed on the roof and connected directly with the air shaft of the building. This fan is a 36-inch disc fan with a capacity of 6,500 cu. ft. per minute. From this air shaft ducts are run to the different rooms on the second floor, terminating in registers set in the walls near the ceiling.

Room or floor	Register area sq. ft.	Observed velocity outgoing air, ft. per minute	Quantity in cu ft. per hour	Cubic contents of room	Number changes per hour
Butler's pantry..	0.370	243	5394.60	953.25	5.65
Dining room ...	0.444	211	5621.04	2472.81	2.27
Library	0.889	404	21549.36	2460.00	8.76
Corridor	0.889	446	23789.64	2788.00	8.53
Bath-room	0.444	327	8711.28	992.97	8.78
Third floor	1.334	1020	81640.80	17068.80	4.78
Third floor toilet	0.139	754	6288.36	311.75	20.17
Fourth floor	1.334	1075	86043.00	17068.80	5.04
Fourth floor toilet	0.139	845	6793.80	357.50	19.00

The butler's pantry has one register, 10 in. by 8 in., the dining room a 12 in. by 8 in. register, the bath-room a 4 in. by 24 in., the library an 8 in. by 24 in., and the color Booth No. 3 in the corridor, for the purpose of ventilating the corridor, a 12 in. by 16 in., register. The third floor has one large register, 12 in. by 24 in., and a smaller register in the toilet, 5 in. by 6 in. This layout applies also to the fourth floor. Tests made with a standard anemometer at the different register faces show the preceding results:

The above table shows the quantity of air handled, but does not give any indication of the pureness or temperature of the average air in the rooms in the apartment, or on any of the other floors. To determine this a series of tests was run for the determination of the temperature, humidity, amount of CO_2, and amount of oxygen present on each floor. These tests were made with the lighting installation on each floor in operation, and the ventilating system also in operation, the whole test taking place during ordinary business hours. As a comparative test the same determinations were made on the fifth floor where no gas except that used in the pilots of the seven lights, had been burned for 16 hours, and where the only persons on the entire floor were the two experimenters. In running this test, two stations were established at each of which two samples of air were taken, one at the ceiling, and one at a level of 5 ft. 3 in. above the floor, this being assumed as a fair average figure for the head height, or in other words the height of the stratum of air which surrounds the breathing organs. Temperatures and humidity were taken at the same stations that the samples were, and also samples of air from the outside at both the beginning and ending of the test with their temperatures and humidity. The samples of air were analyzed for CO_2 and oxygen. The instruments used were the Petterson-Palmquist CO_2 apparatus, the Elliott Pyro Oxygen apparatus, and an Assman Aspiration Psychrometer. The fifth floor test resulted as follows:

FIFTH FLOOR.

Time	Station	Percentage CO_2	Percentage oxygen	Temperature degrees C.	Humidity grains H_2O in 1 cu. ft.	Remarks
1:45 P. M.	Outside	0.0400	20.9	2.7	1.850	
2:15 "	Ceiling	0.0675	20.8	14.8	2.007	
3:00 "	5′3″ level	0.0650	21.0	14.8	[illegible] 258	
3:35 "	Ceiling	0.0700	21.0	15.4	2.[illegible]	
4:00 "	5′3″ level	0.0700	21.0	13.8	2.135	
4:30 "	Outside	0.0375	21.0	3.4	1.859	

From this it is evident that the oxygen and CO_2 in the air, both at the ceiling and at the 5 ft. 3 in. level, were very nearly the same inside as outside.

On the fourth floor three stations were established, and samples and temperatures taken as described before. During this test, the full lighting installation if nine 4-light reflexoliers was in operation, having been lighted at 9 A. M., and the floor was occupied by six persons continually, the two making the test only being there while taking samples. The ventilating fan was in operation during this test, as in all subsequent tests given. The gas consumption on this floor during the tests was 120 cu. ft. per hour. The results follow:—

FOURTH FLOOR.

Time	Station	Percentage CO_2	Percentage oxygen	Temperature degrees C.	Humidity grains H_2O in 1 cu. ft.	Remarks
9:30 A. M.	Outside	0.0360	20.9	7.4	2.879	Ven-
10:35 "	Ceiling	0.0800	21.0	24.6	3.388	tilat-
11:00 "	5′3″ level	0.0825	20.9	23.4	3.433	ing
11:40 "	Ceiling	0.0800	20.9	25.0	3.249	fan in
12:15 P. M.	5′3″ level	0.0750	20.8	23.1	3.562	opera-
1:00 "	Ceiling	0.0800	20.9	25.8	3.500	tion
1:10 "	5′3″ level	0.0800	20.9	24.0	3.649	
2:00 "	Outside	0.0400	21.0	10.4	3.125	

From these figures it can be seen that the increase in CO_2 in the inside atmosphere over that in the outside is entirely negligible; that the oxygen remains the same, and that the difference in the humidity is very slight. These can be considered perfect conditions as regard ventilation, as the increase in CO_2 can be more than accounted for by that given off by the occupants of the room.

The tests on the third floor were similar to those on the fourth. The full equipment of 26 Reflex lights was lighted at 9 A. M., giving a gas consumption of 85 cu. ft. per hour, and the usual clerical force of 15 was continually in the room, while the two testers were present only while taking samples. The results follow:—

THIRD FLOOR.

Time	Station	Percentage CO_2	Percentage of oxygen	Temperature degrees C.	Humidity grains H_2O in 1 cu. ft.	Remarks
10:45 A. M.	Outside	0.0400	20.9	5 4	1.893	Ventilating fan in operation
11:15 "	Ceiling	0.0900	21.0	27.0	2.813	
11:55 "	5′3″ level	0.0850	20.9	22.4	2.677	
2:35 P. M.	Ceiling	0.0800	20.9	27.2	2.785	
3:00 "	5′3″ level	0.0800	21.0	23.6	2.704	
3:25 "	Ceiling	0.0900	20.9	27.0	2.945	
3:55 "	5′3″ level	0.0925	20.9	24.0	2.629	
4:25 "	Outside	0.0400	21.0	5.2	1.821	

Here again the increase in CO_2 is very slight, and can be more than accounted for by that given off from the occupants of the room; the oxygen is constant and the humidity but slightly higher, while the temperatures at the ceiling and 5 ft. 3 in. level are practically the same, the greatest difference being 3.6° C.

The second floor presented a different proposition. One station was established in each room at as nearly an average position as possible, in reference to the lighting fixtures and the ventilating registers. During the tests the following lights were burning, having been started at 9 A. M. Reception room—7 Reflex. Corridor—3 Reflex and single Re-

flex in each of booths Nos. 1 and 5. Library—1Reflex in center dome, 3 Ramsdell Bijou inverted burners, 2 Welsbach Juniors in mantle standards, and one large Welsbach in portable lamp. Dining room—center dome with four small upright Welsbachs and two side brackets with a Welsbach Junior in each. Bath-room—two sidebrackets with Welsbach Juniors, and kitchen—all the fixtures, making a total of 6 Reflex, and giving a grand total gas consumption of 146 cu. ft. per hour. The number of occupants of the apartment during the test was three, with the two making the test only in the rooms while taking samples. The results follow:

SECOND FLOOR.

Time	Station	Percentage CO_2	Percentage oxygen	Temperature degrees C.	Humidity grains H_2O in 1 cu. ft.	Remarks
9:30 A. M.	Outside	0.0400	21.0	3.8	1.999	Ven-
	Reception room					
10:05 "	Ceiling	0.0800	20.9	39.2	2.128	tilat-
10:35 "	5′3″ level	0.0850	20.9	22.4	2.574	ing
	Booth No. 1					
11:10 "	Ceiling	0.1600	20.9	44.0	3.579	fan in
11:40 "	5′3″ level	0.0800	20.9	25.7	2.673	opera-
	Corridor					
12.05 P. M.	Ceiling	0.1250	20.9	44.0	2.722	tion
12:30 "	5′3″ level	0.0975	20.9	21.6	2.479	
	Bath-room					
2:20 "	Ceiling	0.0975	20.9	27.2	2.597	
2:50 "	5′3″ level	0.0850	20.9	21.4	2.686	
	Library					
3:30 "	Ceiling	0.0875	20.9	30.4	2.592	
4.00 "	5′3″ level	0.0775	20.9	22.6	2.775	
	Dining room					
4:10 "	Ceiling	0.1475	20.8	35.0	2.677	
4:50 "	5′3″ level	0.0900	20.9	23.8	2.804	
	Kitchen					
5:00 "	Ceiling	0.0850	20.9	34.4	3.166	
5:45 "	5′3″ level	0.0825	20.9	22.2	3.249	
5.55 "	Outside	0.0325	21.0	9.0	2.309	

From these results it can be seen that on this floor where the conditions for natural ventilation are extremely poor, in fact where, excepting in the reception room and the kitchen, there is absolutely no means of natural ventilation, that in no case is the increase of CO_2 sufficient to vitiate the air, while the oxygen is practically the same as in the air outside, and the humidity is but very slightly higher, even after eight hours of continuous run. The CO_2 found in Color Booth No. 1 at the ceiling, is necessarily high for the formation of this booth makes the top a pocket which nothing short of a direct current of air would influence. This is also true in a lesser degree of the corridor and dining room.

The store floor presented again different conditions as to occupants and direct connection with the outside atmosphere. Here the entire lighting installation of 28 Reflex lights was put in operation at 7 A. M., and six Reflex lights in each window were lighted at 2:15 P. M. During the tests there were four persons in the store continually and a total of 30 customers whose stay varied from five minutes to twenty minutes. Each time a customer entered the store meant an opening of the door and therefore a direct communication with the outside air. The two persons making the test were only in the store while taking samples. The gas consumption during the tests was 110 cu. ft. per hour. The results follow:

First Floor.

Time	Station	Percentage CO_2	Percentage oxygen	Temperature degrees C.	Humidity grains H_2O in 1 cu. ft.	Remarks
10:00 A. M.	Outside	0.350	20.9	10.6	3.273	
10:35 "	Ceiling	0.0450	20.9	23.2	3.467	
11:10 "	5′3″ level	0.0450	21.0	17.0	3.411	
11:45 "	Ceiling	0.0525	20.9	23.8	3.292	
12:15 P. M.	5′3″ level	0.0475	20.9	18.2	3.523	
1:50 "	Ceiling	0.0450	21.0	25.6	3.303	
2:25 "	5′3″ level	0.0450	21.0	18.4	3.901	
3:05 "	Outside	0.0375	21.0	11.0	3.637	

This floor, as the results of the test show, has the same air conditions, with the exception of the temperature, as are found outside.

The basement air was tested in the same manner as the previous tabulated floors, samples being taken at the ceiling, and head level at three stations. The arc lamps were lighted at 7 A. M., and burned constantly during the test, giving a gas consumption of 140 cu. ft. per hour. The only occupants of the floor while the test was being run were the two who were making the same, and the ventilating system, using the motor driven fan, was in operation, with three large registers and nine of the 6 in. diameter ports open. The results were:

BASEMENT.

Time	Station	Percentage CO_2	Percentage oxygen	Temperature degrees C.	Humidity grains H_2O in 1 cu. ft.	Remarks
10:45 A. M.	Outside	0.0300	21.0	2.0	1.488	Ven-
11:35 "	Ceiling	0.1600	20.8	21.8	2.454	tilat-
12:25 P. M.	5′3″ level	0.1000	21.0	20.6	2.428	ing
2:30 "	Ceiling	0.1150	20.8	26.4	2.766	system
3:10 "	5′3″ level	0.0900	21.0	21.0	2.381	in
3:40 "	Ceiling	0.0800	20.9	28.2	2.470	opera-
4:00 "	5′3″ level	0.0800	20.9	21.1	2.313	tion

These results show a negligible increase in CO_2 and practically no change in the oxygen, with a slight increase in the humidity, or, in other words, good, pure air.

With this consideration of the ventilation, and related closely to it, is the subject of heating. This building is equipped with direct steam radiation, the steam being supplied by a gas boiler located in the basement. This boiler does away with all dirt and dust attendant on the handling of coal and ashes, and the boiler itself occupies only about one-third the floor space that the coal boiler, which it displaced, occupied. Again, through a system of thermostats on all floors, and through the automatic regulation on the boiler itself, as nearly me-

chanical a regulation as possible is secured. The thermostats are set at the temperature desired to be maintained, and when this point is exceeded the radiator valves are closed. This causes a rise of steam pressure at the boiler, which, when it reaches the point at which the mechanism is set, reduces the gas supplied to the burners. As soon as the pressure drops, due to the radiators being opened by the thermostats, the gas is increased on the burners. Thus a complete and most economical system of automatic control is secured, the boiler only burning enough gas to supply the actual steam needed to keep the temperature of the building at the desired point.

The building here described is completely equipped with gas, using it for lighting and heating, for hot water supply, and for demonstrating the various appliances. The building has every improvement and recent development in all branches of the gas appliance and lighting fields, not only on demonstration, but in actual operation. The lighting installations have been in constant operation for over a year, and show on the tests cited both efficiency and economy. The ventilation is practically perfect, the air being as fresh and as pure as the outside atmosphere. This demonstration so attractively and effectively fitted out should go a long way to overcome the prejudice, which still exists in some minds, against the use of gas for lighting or heating.

Mr. Norman Macbeth: Mr. President and gentlemen, it would be a very good thing ideed if more gas companies had such show rooms as have been here described. We constantly hear talk of the depreciation in gas illumination and its short comings. When you look back over the field, you can hardly blame the consumer today for using fewer gas lamps and more of the electric. The consumer's judgment has been so largely influenced by the open flame burner and there are so few gas offices where they show what really can be done with gas illumination. I have been through a number of show rooms at different times and have observed what visitors to

these rooms had to say about certain lamps and many times I have heard the remark: "You mean to tell me that these results are secured with gas lamps; that this is gas you are using here?"

When you remember how old the gas business is and consider how few show rooms there are in this country, and that these or similar show rooms have not been open to the public for seventy years, or even ten years, and most of them for one, two or three years you can readily understand many of the so-called disadvantages of the gas business.

There are commendable points in this paper that can very easily be adapted to any gas show room with advantage. Take the color booths shown and illustrated on page 400. I do not know of a more practical and forceful demonstration for the average consumer than to look over this color booth and note the effect with various colorings on the walls and the resultant illumination on that table.

There is one point I should like to bring out here in connection with the table shown on page 401 giving the percentages of the illumination values with these various colored walls. It has not been stated that these values represent the coefficients of reflection of those colors but it is possible that in reading the table over hurriedly some members might conclude that the values were representative.

With this small room, four feet by five feet with the lamps equipped with reflectors directing 90 per cent. of the light downwards from a point approximately five feet above the table a considerable part of the light received on the disc of the photometer at the table height would be direct from the lamp; however, had the bottom of the lamp been screened in such a manner as to cut off all direct light then the light received on the photometer screen would be that reflected from the side walls and would possibly give a fair indication of the light reflecting value of those walls under similar conditions. I am merely bringing this point up because, as stated a wrong assumption is possible.

There is not a show room in this country where they can at as slight an expense make a demonstration which will mean so much to the public. It is not perhaps necessary to have six booths. You may have one booth and use colored window shades on rollers, which may be pulled down over the three walls showing the effects on the changes in color.

Throughout this entire show room the question has evidently not been, what will these fixtures cost? How cheaply may this be fitted up? But how good, and that is a very excellent answer to the one point constantly recurring when you bring up the question of gas illumination "Oh, gas is cheap"—"the fixtures are cheap" and don't you know, gentlemen, I think when you come right back home with it, that we ourselves, are largely responsible for that assumption on the part of the consumer. If all you have to show are cheap fixtures you cannot expect the consumer to go out of his way to buy something from a paper representation, from an advertisement or from a free hand sketch, when some one else is prepared to show him a finished electric fixture. They can get a much better idea of what we have when we exhibit the completed connected fixture.

This may seem irrelevent, bringing in points of this kind, but I have really been in towns where the gas man said there was not much sale for gas illumination, and he did not have a single lamp in his show room, not a thing to show the people what they could get; they depended upon the department store and the dealer.

On page 404 in the second line a phase was used "Removing all chance of the intensity of brilliant light sources coming into direct line of vision." Now, that is an electrical term and it belongs to the electric man. It does not belong to the gas business. The specific intensity or intrinsic brilliancy of a mantle has been variously given at from 25 to 50 c-p. per square inch. The highest factors I have secured with low pressure gas do not exceed 80 candle-power per square inch. Now

that intensity can be specific intensity of a thousand candle-power per square inch which is not unusual with the latest incandescent electric lamps.

One of the members in conversation the other day brought up the question that our lamps did not compare satisfactorily with the electric when the consumer looked first at the incandescent mantle and then at the electric filament. We do not want them to be compared that way. We have in the incandescent gas lamp what they have not got in the electric, and which they cannot get without a very considerable reduction in efficiency; that is, a low specific intensity or intrinsic brilliancy. The electric man would give a great deal for this advantage, the value of which I do not think we fully appreciate. If we can say a source having a specific intensity of 25 to 80 candle-power per square inch is "intensely brilliant" where are our superlatives coming from to describe the thousand candle-power per square inch.

I should like to criticize that fixture in the butler's pantry. It is a fixture such as is very commonly used in kitchens all over the country, a light three-eighths stem, three or four feet long with an upright mantle. I do not know of any fixture in the house which will do as much to depreciate gas illumination as that kind of fixture with that kind of lamp. There is constant breakage. You can hardly touch the lamp, turn a key or pull a by-pass chain without whipping the skirt off the mantle. In a short time the mantle or cylinder is gone and mantle lamps come in for severe criticism when the fault is due entirely to a cheap, flimsy fixture. With an inverted lamp a foot or eighteen inches below the ceiling, using a by-pass with a long chain, you will never have that difficulty nor have any mantles broken to speak of. I have known mantles on lamps so installed to run two years without any attention. The illumination measurement here given should not be compared with those reported a year ago on these same floors without a careful consideration of how these measurements were taken and what they represented. They should be looked into

carefully. The discrepancies do not show depreciation nearly so much as might be assumed.

The latter part of the paper covering the ventilation, temperature, and CO_2 content of the room, is extremely interesting. A number of tests of this kind have been reported at different times but we cannot have too many of them and I might say here that the gas man is the hardest man to convince on that question of ventilation by utilizing the heat from the gas lamps.

Dr. Samuel Rideal reported, in the Journal of the Sanitary Institute in a paper covering 83 pages, an investigation of temperature and CO_2 content conditions in a room, with a number of operators using both gas and electric lamps. They were unable to find any difference, that is any appreciable difference, whether gas or electricity were used in that room except that in a small room the ventilation was decidedly better with gas than with electricity. These points may seem of greater importance to me because they are most frequently brought up. I have had a great many gas men asking for answers to various points brought up from time to time and the one particular point that is constantly returning is this question of vitiation of air and increased temperatures.

The distributed unit system described on the third floor is coming into quite general use. I believe it has even a wider field especially in rooms having comparatively low ceilings. A member in speaking to me stated that he found this method very satisfactory in certain rooms in his own home to use a single inverted lamp on the ceiling within a foot or eighteen inches of the ceiling. I have three or four rooms equipped in this way and the general experience has been that the family prefer to read and sit in the rooms so illuminated. That is the best we can do in residence work with the fixtures and lamps now available. For residence work our lamps are generally too large. You will not find a fixture man who will care to put in a fixture having less than three lights. Consider the ordinary three and a half foot lamps now used, you would not be pleased to use three lamps of that size in a room in the

ordinary residence. You may have three small open flames but when you consider that you have at least five times the quantity of light per cubic foot of gas with mantle burners, the open flame should not be considered as available.

We need more small lamps and then we can claim more attention to residence work and can deliver the effects desired and keep within the minimum appropriation.

THE PRESIDENT: Is there any further discussion on this paper?

MR. GIFFORD: I should like to ask a question in regard to ventilation. Where are the air outlets with reference to the upper or lower parts, and are they so placed that when the fans are not running the heat from the burning gas will do some ventilating? Unfortunately some of our show rooms are not equipped with fans for ventilation.

MR. WARING: Mr. President, in regard to the illustration in Figure 12, I should like to ask if the products of combustion from the instantaneous water heater are allowed to escape directly into the room and depend upon the action of the fan to remove these products of combustion. It would seem to me, that in a modern bath-room, this instantaneous water heater should have a good flue connection. It may have such a connection, but if it has, it is not clearly shown in the cut.

THE PRESIDENT: While I do not intend to discuss the paper, I can see no reason why a gas company should not take as much pains to display its goods to the public as do the dry-goods merchants, the milliners or the clothiers. If there is no further discussion Mr. Schofield will please answer the questions that have been asked.

MR. SCHOFIELD: In regard to what Mr. Macbeth said, first on the coefficients, I think it is definitely stated in the paper that it was not the intention to assume those values as coefficients of reflection of those colors. I did not mean to steal any of the electric people's thunder in the matter of intensely brilliant light sources, and the point Mr. Macbeth brought out

had not occurred to me before. I also plead guilty to the fact that the fixture in the butler's pantry, as suggested by Mr. Macbeth, could be improved upon; and in the illumination fixtures on the store floor it is undoubtedly true that the illumination in the front part of that floor is considerably higher than in the rear of the room; and if the calculation had been made on simply the rear room instead of taking it for the entire floor, it would have brought a higher figure than 70.13. In answer to Mr. Gifford, the air outlets are all practically at the ceiling, and in that way the heat from the burners and the ventilating fan both aid in the ventilation. In answer to Mr. Waring, the instantaneous water heater in the bath-room has a flue connection. Unfortunately the picture does not show it.

The President: Gentlemen, Mr. Schofield has given us a very instructive paper. I would suggest a vote of thanks.

A vote of thanks to Mr. Schofield for his paper was then duly carried.

The President: The next paper is

Laying a 48 in. and two 36 in. Gas Mains Under the Harlem River.

by Mr. C. C. Simpson.

Mr. Simpson then read his paper as follows:

LAYING A 48 IN. AND TWO 36 IN. MAINS UNDER THE HARLEM RIVER.

48 inch Main.

The 48 in. main was laid for the purpose of insuring an additional supply of gas for Bronx Borough.

The Borough of the Bronx is practically a city of itself, with a population of 430,000. The capacity of the Central Union Works, which supplies the entire Borough, is 11,000,000 cubic feet per day, with very little, if any, room for extension. The maximum send-out from these works during the winter of 1909-1910 was over 10,000,000 cubic feet.

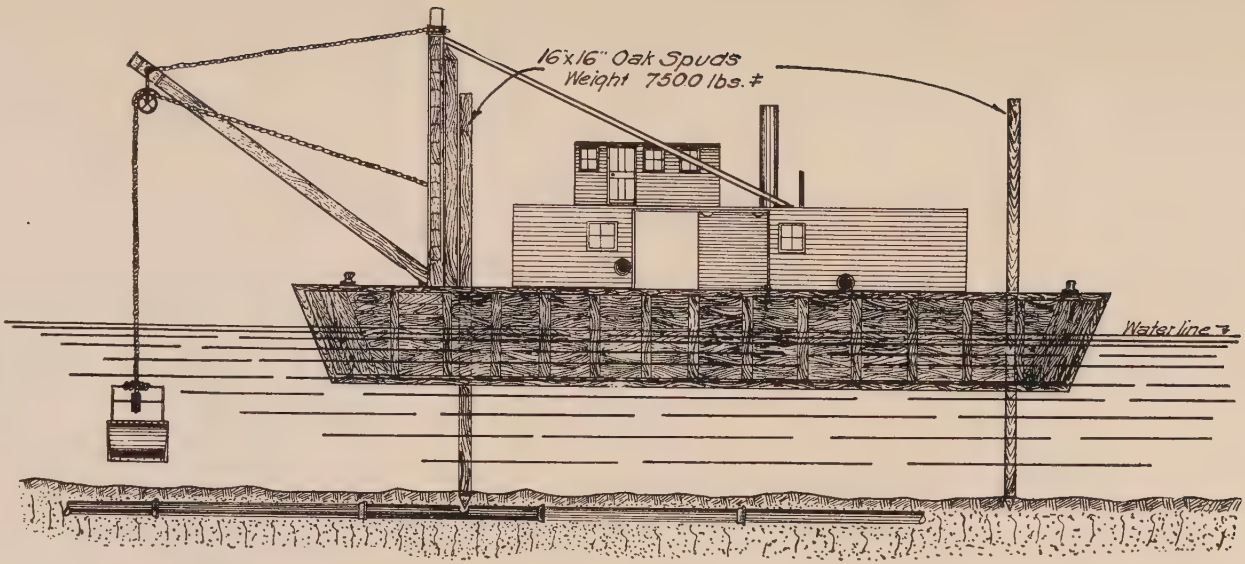
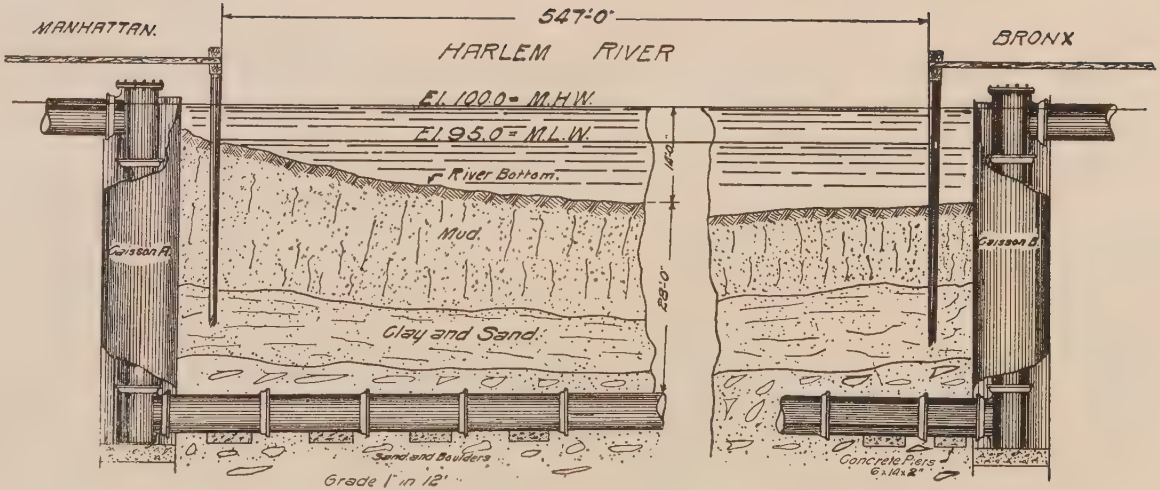


DIAGRAM SHOWING WAY IN WHICH 20" SUBMERGED GAS MAIN WAS BROKEN BY DREDGE SPUD.

Fig. 1.

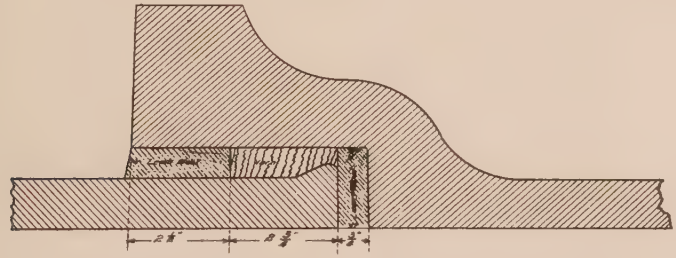


PROFILE OF 48" HARLEM RIVER LINE
LOOKING WEST.

Fig. 2.

From the normal increase of population in this territory, (over 10 per cent. a year) it was evident that steps had to be taken to provide an additional supply of gas. This gas—pending the completion of the Astoria-Port Morris tunnel—must necessarily come from Manhattan. Two methods were considered for bringing gas from Manhattan to the Bronx:

First—to build a tunnel under the Harlem River from 129th Street, Manhattan to Lincoln Avenue, Bronx. Through this tunnel a 48 in. line would be run from the end of the present 48 in. main near 129th Street to Lincoln Avenue, and from that point to the Central Union Works. The cost of



SECTION HUB AND SPIGOT 48" HARLEM RIVER MAIN
SHOWING INSIDE AND OUTSIDE JOINT.

Fig. 3.

this tunnel, taking into consideration the purchase of sites for the two shafts, would have been not less than $500,000.00, and the difficulty of obtaining franchises and acquiring suitable property would have made the minimum time of construction two years.

The second scheme was to replace the present 20 in. main at this point with a 48 in. main, laying it at such depth below the bed of the river so as to insure against any possibility of damage from the buckets, anchors or the heavy, steel-shod-spuds of dredges operating over the line of the main, and also to provide for any future deepening of the channel. (Fig. 1 shows the manner in which the former 20 in. main at this point was

put out of service by a dredge spud.) The cost of this second scheme would be less than $150,000.00, and the work could

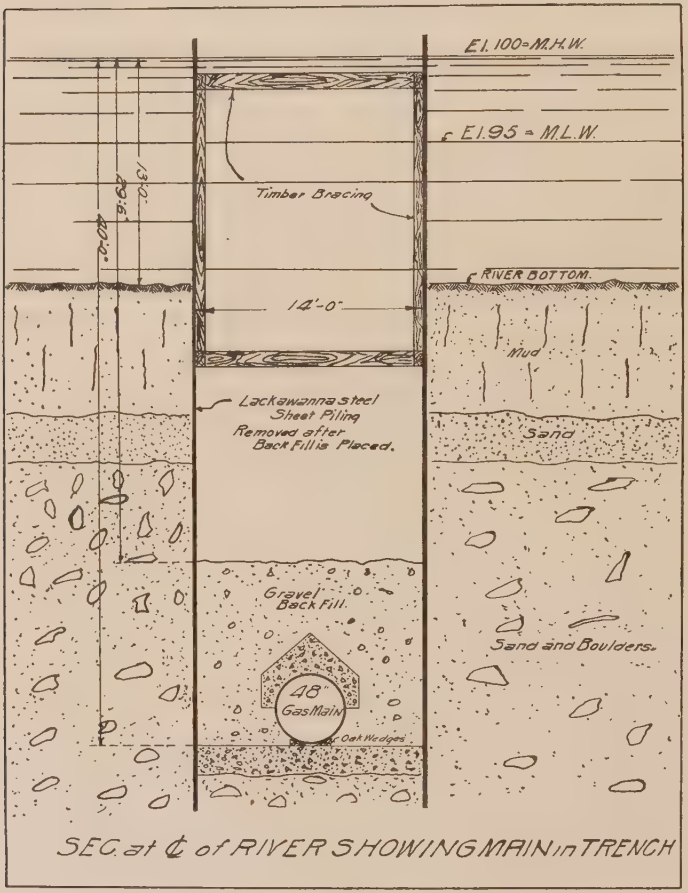


Fig. 4.

easily be finished in from six to nine months, thus allowing us to furnish gas in this way during the coming winter.

Taking into consideration, then, the items of time and cost, the second method of crossing the river was adopted. The

general plan for carrying out this work (see Fig. 2) was as follows:

Steel caissons 10 ft. in diameter were sunk just back of the

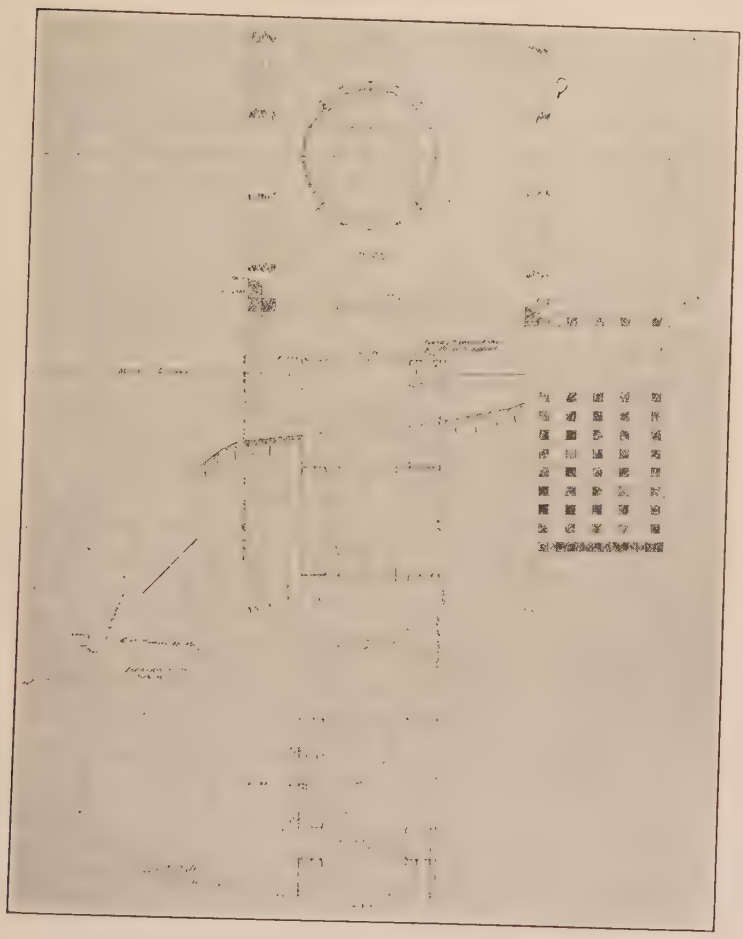


Fig. 5.

bulkhead line on each side of the river. The bottoms of these caissons were then sealed with concrete, a drip pot was placed in each, and the standpipes built up inside. Coffer-

dams of steel sheet piling, in successive 125 sections, were then driven across the river, the pipe being laid on concrete piers as soon as the material was pumped out. The channel at this point extends from bulkhead line to bulkhead line,

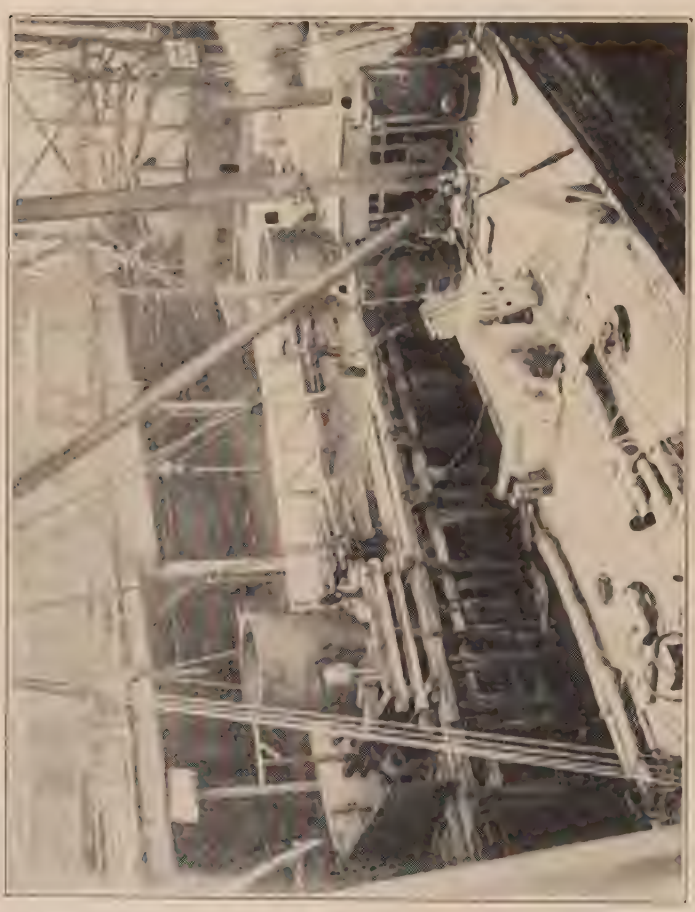


Fig. 6.

(550 ft.) and as there is a great deal of shipping, it would not be possible to close off more than half of the river at any one time.

The pipe used was ordinary water-weight (8,400 lbs. per

length) hub and spigot pipe, the depth of hub being 6 in. An inside joint ¾ in. wide (see Fig. 3) was provided by not allowing the spigot to enter the full depth into the bell. As an additional precaution against breakage, and also to weight

Fig. 7.

the pipe, a complete decking of concrete blocks was placed over the main. (see Fig. 4).

The actual work started with the sinking of Caisson A on the Manhattan side of the river. Fig. 5 shows the general

design of this caisson, which is composed of sheets of ⅝ in. boiler plates. A guide frame of 12 in by 12 in. timbers was erected, and through this the first four sections were lowered by means of the derrick scow, until the cutting edge had

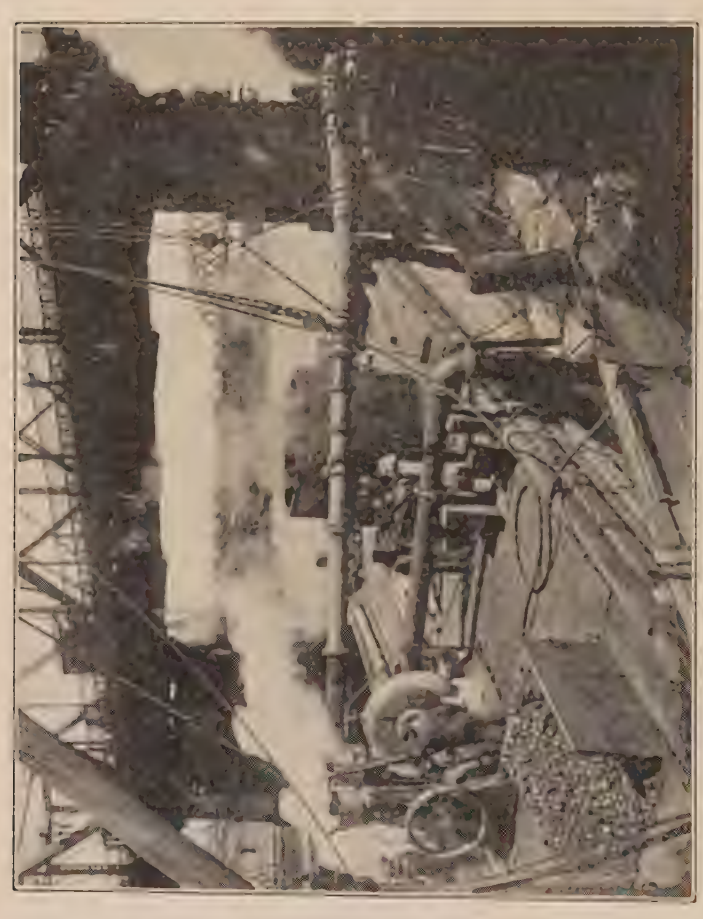


Fig. 8.

penetrated five or six feet into the mud. (See Fig. 6.) Four steel hooks, which had previously been placed under the cutting edge, were then fastened by means of wire cables to

four 4-ton differential blocks, which were in turn secured to the guide frame. This scheme allowed us to hold the caisson at any time to allow the bolting on of additional sections, and also to check the progress should bad quicksand be encountered.

The material inside the caisson was then pumped out by means of an 8 in. centrifugal pump, and a head of water greater than that outside constantly maintained by pumping in with a 12 in. pump. It was necessary to use a diver to tend this 8 in. suction, and also loosen up the material by means of a water jet.

Additional sections were bolted on as the cutting edge was lowered, and on the inside flange of each section a loading platform, holding ten or fifteen tons of pig iron, was placed to help overcome the skin friction. (Fig. 7 shows the 8 in. and 12 in. pipes and also one of the loading platforms. Fig. 8 shows the pumping plant in operation.)

When the cutting edge was within 6 ft. of the final grade, a slight crack was noticed in the street surface near an adjacent elevated railroad column, and levels showed a settlement of this column of about ¼ in. This settlement was due to a layer of quicksand which we had penetrated, and to guard against any further movement we decided to drive a tight ring of steel sheet piling about 6 ft. below the final grade of the caisson. Fig. 9 shows the relations of the column, sheet piling and caisson. After the driving of this piling no further settlement of the column took place, and the caisson was finally sunk to grade. The bottom was then sealed with a layer of concrete and the drip set in place. (Fig. 10 shows caisson "A" sunk to grade and the first coffer dam being driven.)

While this work was going on Caisson "B" on the Bronx side of the river was started. This proved a much simpler matter than Cassion "A," as there were no elevated railroad columns to contend with. The material through which this caisson was sunk was a very sticky mixture of clay and sand.

It was impossible to pump this, so a ¼ cubic yard Hayward orange peel bucket was secured and the material excavated by means of this, with very little assistance from divers. When this caisson had reached grade the bottom was con-

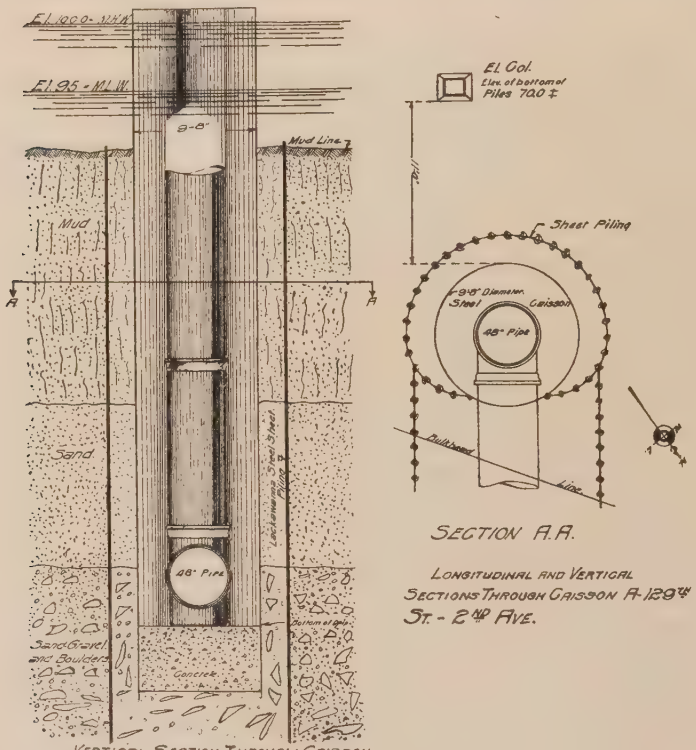


Fig. 9.

creted and work at this point temporarily discontinued until the main had been laid clear across the river. As stated before the large volume of shipping at this point prevented us from closing more than one side of the river at a time.

In laying the pipe in the river the original idea was to dredge an open trench of the required depth, allowing the

banks to take their natural slope. It was finally decided, however, on account of the great depth of the trench and the uncertainty as to what angle of repose the material would take under the action of the strong tide, to drive sectional

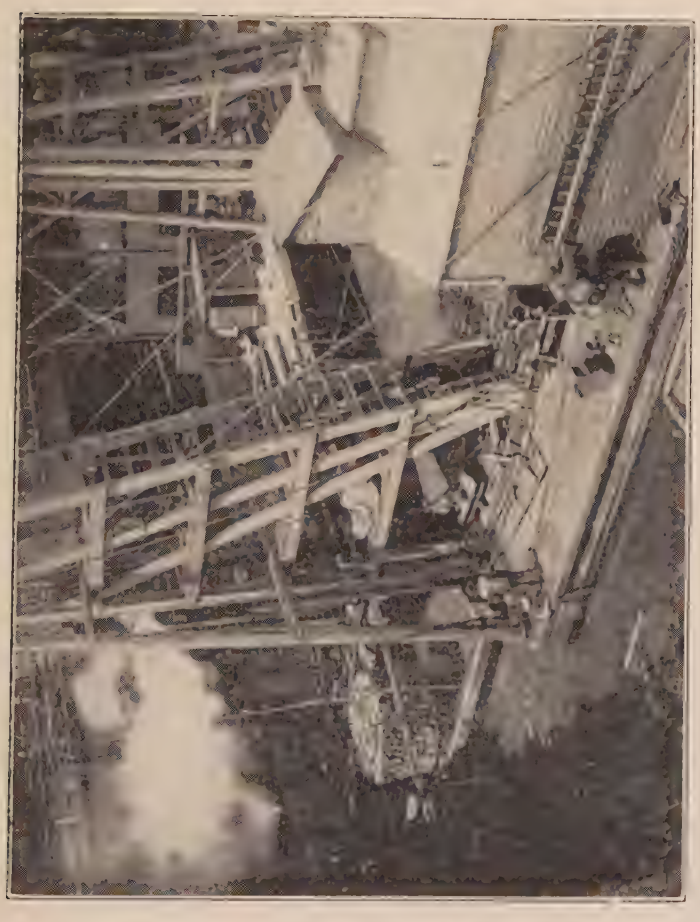


Fig. 10.

coffer-dams of steel sheet piling. While this method might have delayed the work a little it would certainly be much safer in the end, especially as we were unable to obtain any definite information as to the depth of the foundations under

two adjacent piers of a heavy railroad drawbridge. An order was therefore placed for enough of this piling to sheet 150 ft. of trench. Pending the arrival of this piling we pumped the mud from 4 high tension cables which lay di-

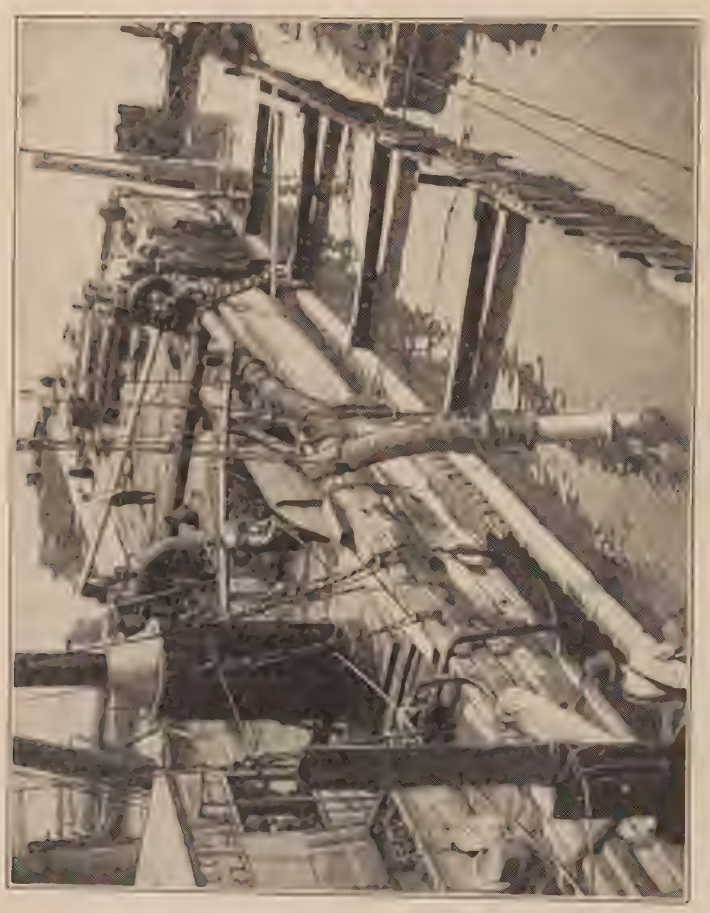


Fig. 11.

rectly on the line of our main. Divers fastened these together and there was fortunately enough slack to allow us to pull them about 15 ft. east, so as to leave them entirely out of danger and clear of our trench. It was necessary to watch

these cables very carefully during the entire process, as any break would have made us liable for heavy damages, besides endangering the lives of the workmen.

The river at this point is about 15 ft. deep at high water. The permit granted for the main required it to be laid twenty feet below the river bed. This would make the bottom of the trench at the center of the river, (which was also the summit of the main) 42 ft. below mean high water. This allows for a concrete pier about two feet thick under the pipe. At the shore ends, allowing a grade of 1 in. in 12 ft., the bottom of the trench was 45 ft. below mean high water.

The first consignment of piling (in 45 ft. lengths) arrived shortly after the cables had been moved, and work was started on the first 130 ft. section of coffer-dam. The piling was driven an average of 4 ft. below the pumping grade by means of a Vulcan Steam Hammer. The work was rather slow at the start, due to a layer of large boulders underlying the sand, but the section 130 ft. long and 14 ft. wide was finally driven to grade and pumping started. (Fig. 11 shows the sheet piling on this section driven and pumping in progress.) This pumping was done by the 8 in. and 12 in. centrifugal pumps worked from the derrick scow, with a diver tending each suction and stirring up the material with a 3 in. water jet. We were able to take out from 100 to 150 yards per day until the layer of boulders was reached. Pumping here became rather difficult and much of the material had to be removed by the divers. (Fig. 12 shows the largest boulder encountered.)

There was originally a rather strong tide at this point and it became considerably stronger after we had dammed off part of the river. This necessitated some heavy cross-bracing to keep the sheeting in shape when the trench had been excavated. Fig. 4 shows a cross-section of this trench with the pipe in place, and also the amount of bracing necessary.

When about 20 ft. of the inshore end of this coffer-dam had been pumped to grade the plate over the lower opening

in the caisson was removed, the first concrete pier, (6 ft. long, 14 ft. wide and 2 ft. deep) placed and the first length of pipe lowered and caulked into the drip. The drip was then centered into the caisson and the standpipe built up. In all cases, in

Fig. 12.

making up the joints on this line, a pair of ¾ in. rods tapered at the ends, were placed across the hub, allowing for an inside joint ¾ in. wide and 2 in. deep. (See Fig. 3.) After the outside joint was caulked these rods were withdrawn by

means of turn buckles, and when a section of pipe was completed and pumped out, men were sent inside to caulk these joints. All the caulking both above and below the water was

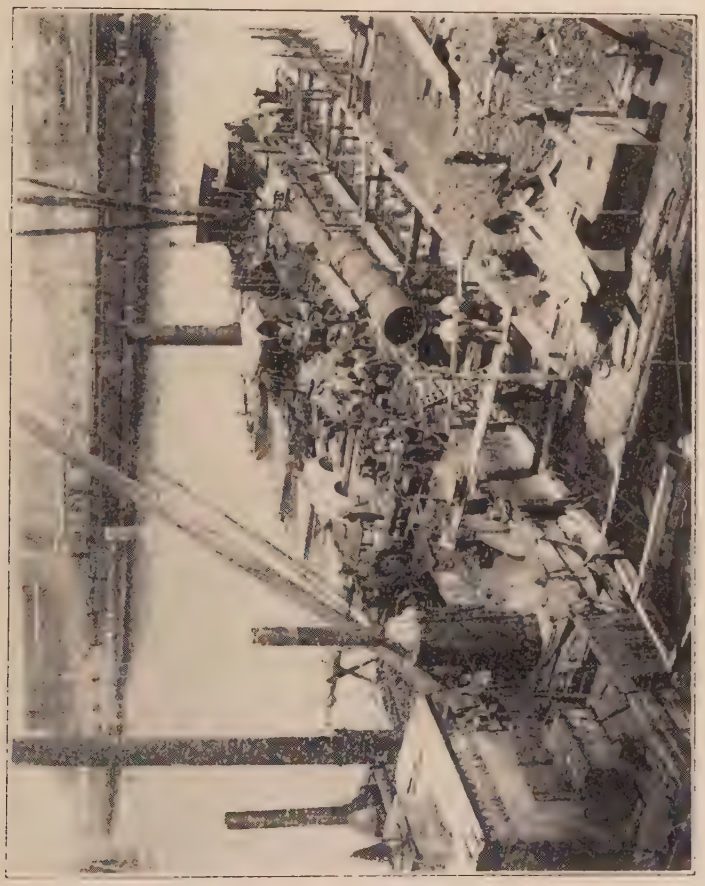


Fig. 13.

done with lead wool and pneumatic tools, considerable time and expense being saved by the use of the latter.

As successive lengths of the trench were pumped out the concrete piers were placed and the pipe lowered and set to grade. The pipe was placed two lengths at a time, the two

lengths being lined up and caulked on the derrick scow, then firmly strapped to a 15 in. I-beam and lowered into place. This made it necessary to have only every second joint caulked under water by the divers. (Fig. 13 shows the method of placing the pipe into the trench.)

In laying pipe under water it is usually a rather difficult problem to preserve line and grade, but on this work it was simplicity itself. Divers first placed heavy wedges under the pipes on the piers. Then by means of a long rod held on top of the pipe and read from an instrument on shore, the divers were signalled to wedge up until the pipe was at the proper grade and the line then checked from the instrument.

After the pipe had all been laid and caulked in this section the end was closed by means of a plug and a rubber gasket, and the water pumped out. An inspection by the engineers in charge was then made and the main found to be absolutely tight and true to line. Advantage of this opportunity was taken to caulk the inside joints and at the same time the concrete protection blocks were lowered into place. As an additional precaution against breakage the trench was back-filled to a depth of four feet above the concrete blocks with gravel. The sheeting was then pulled and driving started on the second section of coffer-dam.

This second section was driven for a distance of 143 ft., carrying us to the center of the river. Both the driving and pumping on this section were much easier than on the first, the layer of boulders seeming to thin out toward the center of the river. The trench was driven, braced and excavated in precisely the same manner as in the first section, and after the pipe had been laid and caulked the water was pumped out and a second inspection made. The line proved absolutely tight and correct as to line and grade, so that the protection blocks were ordered placed and the sheeting pulled.

We decided to make the third section of coffer-dam continuous across the north half of the river, leaving the trench open at both ends and re-driving the sheeting at the north

Fig. 14.

end of the trench, as the pipe was laid and back-filled at the south end.

Two 36 in. Lines:

The two 36 in. submerged lines were laid for the purpose of bringing gas to and from the upper Manhattan Main System and a new 10,000,000 cubic foot holder (point A, Fig. 14).

While the general scheme for this crossing is somewhat similar to that for the 48 in. main above described, there are several points of difference which can best be seen by referring to Fig. 14, showing a plan and profile of the lines.

The river at this point is about 400 ft. wide between established bulkhead lines, and for this distance we decided to keep the top of the pipe 20 ft. below the river bed, the same danger from dredge spuds and future deepening of the channel existing here as at the point where the 48 in. crossing was made. From the west shore line to the west bulkhead line there is 190 ft. of low marsh about 10 ft. below the established street grade. We decided therefore to lay the mains on a low trestle over this ground and to sink the Manhattan Caissons just back of the bulkhead line. From the east bulkhead line to the west line of our holder property, a distance of 620 ft., the land is owned by the New York Central & Hudson River Railroad. As they expect to drive piles and erect buildings on this ground it would have been impossible to lay our mains through it on a trestle, so it was decided to take a gradual slope from the east bulkhead line to the railroad tracks, and then pass under these by means of a concrete culvert.

The actual work on these lines commenced with the building of the trestle from the Manhattan shore to the west bulkhead line. The trestle was built to such a grade that when the street was finally filled in the mains would lie about three ft. below the surface. (Fig. 15 shows the trestle in course of construction.)

At the outshore end of this trestle, where we expected to

sink the caissons, there was but a foot and a half or two feet of water at high tide, and as all the work had to be handled from scows it was necessary to dredge out an area about 60 ft. by 100 ft. During this dredging a tough layer of clay and

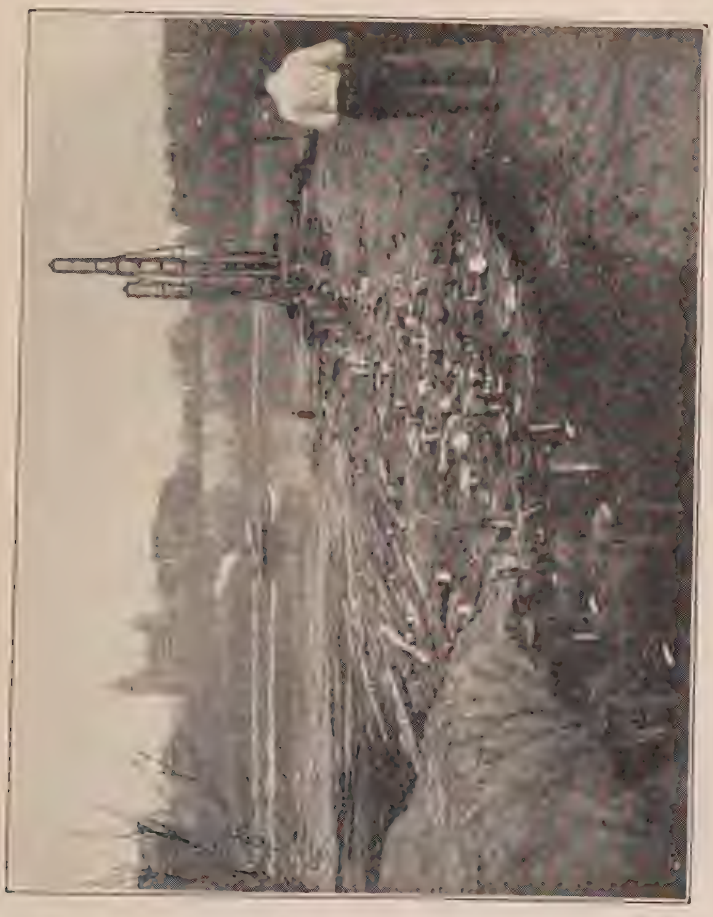


Fig. 15.

sand was encountered just below the mud line. This would have been almost impossible to pump, so it was decided to have the dipper dredge remove this layer for the whole width of the river.

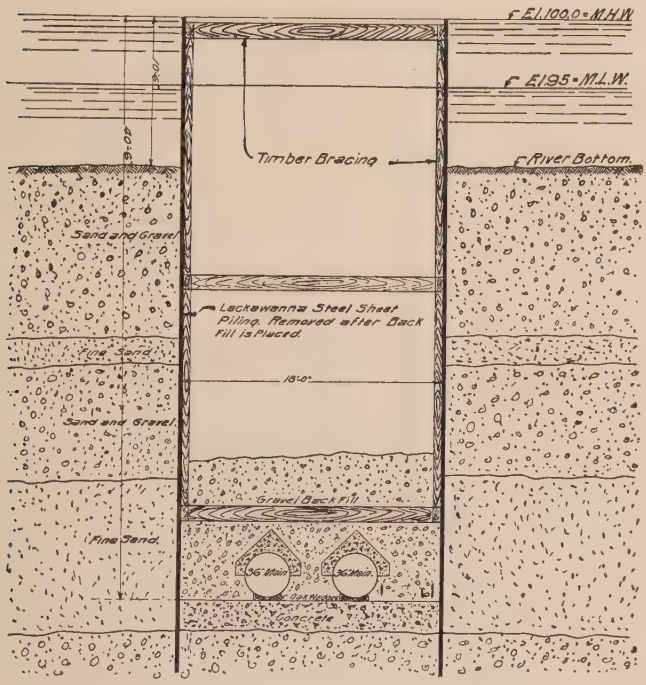
When the dredging was completed guide frames for the caissons were erected and the first section lowered into place. These caissons were of the same type as those used on the 48 in. line but were one ft. less in diameter (9 ft.) The total

Fig. 16.

length of each caisson was 49 ft. and the final grade to which they were to be sunk was 49 ft. below mean high water. As the material here was all sand and as there was no possible

danger of disturbing any piers or foundations (there being none to disturb), we decided to sink the caissons by pumping below the cutting edge with centrifugal pumps, at the same time loading them with enough pig iron to overcome the skin friction.

Conditions were ideal here for this class of work and the



CROSS SECTION of 36" RIVER LINES.
Looking East.

Fig. 17.

two caissons were sunk to grade in a total of 148 working hours. The bottom of each was then sealed with a layer of concrete and the drips lowered in place. (Fig. 16 shows the two caissons sunk to grade.)

Work was then commenced on driving the steel sheet pil-

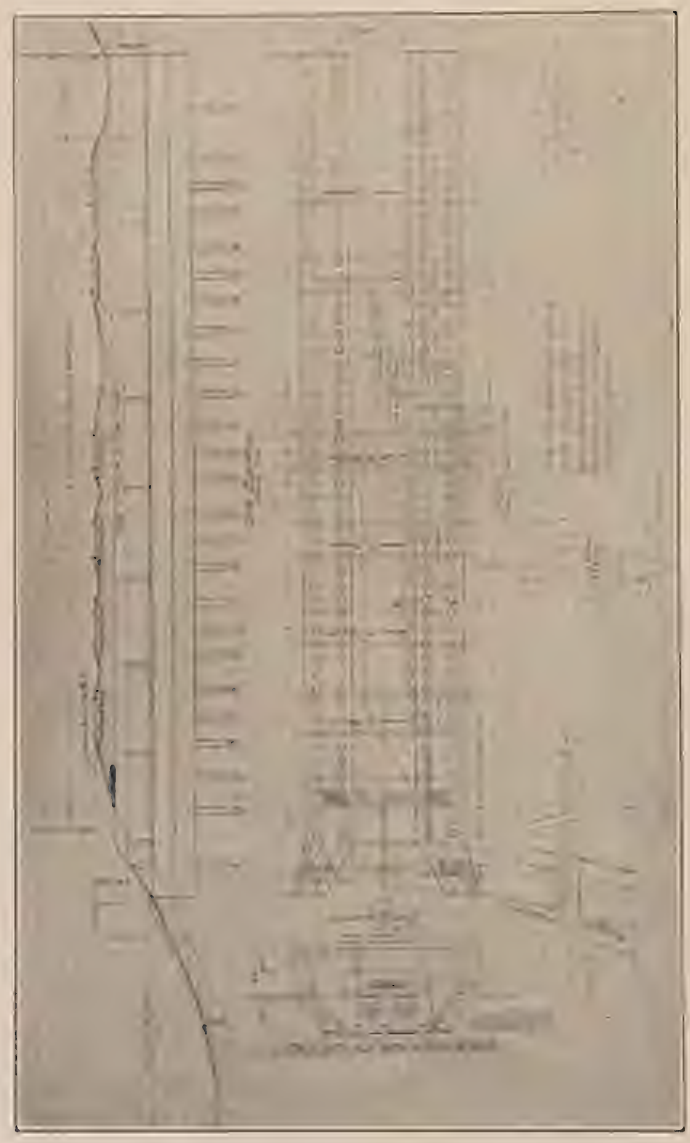


FIG. 15.

ing for the first 120 ft. section of coffer-dam. This piling was furnished in 45 ft. lengths and was driven about 3 ft. below the pumping grade, which at this point was 45 ft. below mean high water. To allow plenty of working room for laying the pipe the trench was made 18 ft. wide. On completion of the coffer-dam pumping was started, a 12 in. and an 8 in. centrifugal pump handling about 150 cubic yards per day. The material to be pumped was mostly sand with a little gravel and small boulders, which latter did not prove at all troublesome.

There is a four or five mile per hour tide at this point in the river, and it was found necessary to brace with 12 in. by 12 in. timbers, as shown in Fig. 17, a set of these braces being placed every 10 ft. There was also a considerable pressure exerted on the sheet piling, due to the weight of the material outside.

As fast as sections of the coffer-dam were pumped to grade the concrete piers were placed and the pipes set in place. The pipe used on this work was the ordinary water-weight (5,200 lbs. per length) hub and spigot pipe with a depth of hub of 5 in. A ½ in. inside joint, similar to that described for the 48 in. line, was provided for in each length. The pipe was lowered, graded, lined and caulked in exactly the same manner as the 48 in. line previously described.

Concrete protection blocks similar in shape to those used on the 48 in. line were then placed over the pipe, the trench back-filled with clean gravel to a depth of 4 ft. above the top of the blocks, and the sheet piling pulled and driven ahead for the next section of coffer-dam.

While this river work was in progress work was started on the concrete culvert under the six tracks of the New York Central & Hudson River Railroad. The general design of this culvert is shown in Fig. 18. This work was very slow and difficult on account of the frequent passing of trains on the six tracks. We were practically obliged to tunnel the

whole distance, and it was necessary to build a coffer-dam at the outshore end to keep out the tide water.

THE PRESIDENT: Gentlemen, you have heard Mr. Simpson's paper. If any of the gentlemen would like to ask any questions or have any other information, we should be glad to hear from them (no response.) As there appears to be no further information wanted on that subject, I think a vote of thanks to Mr. Simpson is in order.

A motion was made, seconded and carried that a vote of thanks be given to Mr. Simpson for his paper.

THE PRESIDENT: The next paper is

THE LAYING OF A PAIR OF 30 IN. CAST IRON MAINS UNDER THE PASSAIC RIVER OPPOSITE THE CITY OF NEWARK, N. J.
BY MR. A. H. STRECKER.

Mr. Strecker is not here; I think he is in Europe. Mr. Earnshaw, will you kindly read the paper.

Mr. Earnshaw then read Mr. Strecker's paper as follows:

THE LAYING OF A PAIR OF 30 INCH CAST IRON MAINS UNDER THE PASSAIC RIVER OPPOSITE THE CITY OF NEWARK, N. J.

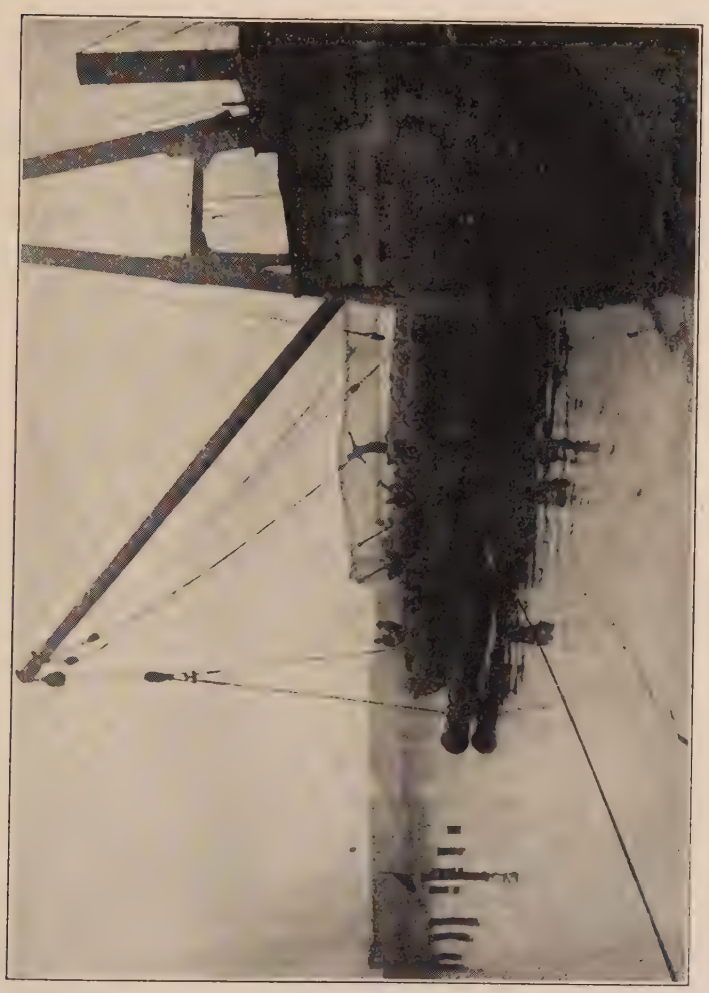
Notes on laying a pair of 30 inch cast iron mains under the Passaic River opposite the City of Newark, N. J.

These notes are written as a companion to a paper on the laying of a 48 inch gas main under the Harlem River in the City of New York to be read at the 1910 meeting of the American Gas Institute.

While our pipes do not in size come near this 48 inch main, neither are they laid as deeply, nor is the channel under which they pass as wide, yet their laying presents some peculiar features and the recording of the same may be of general interest.

The Passaic is a navigable stream flowing at the point in question between the lands of the Gas Company in Newark on the South and in Harrison on the North shore. Its width

between bulk heads is but 320 feet, but since the pipe lines slant well off towards the East, they measure 363 feet be-



tween the intersections of their center lines with the bulk head lines on each shore.

The Gas Company had in use since 1888 a pair of 12 inch

mains, which had been laid under the stream a little further East and which had given considerable trouble. They were heavy cast iron pipes provided with "Ward" ball and socket joints, which had been jointed together on the North shore and dragged across in one piece. Divers had been expected to make the two lines of pipe solid on the bottom of the trench excavated for their reception, but as a matter of fact this was evidently not properly attended to, since later on it was found that they had settled, forming pockets in which water collected, the removal of which caused us much trouble, expense and anxiety.

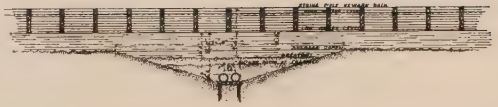
Thus forewarned we set out, in the laying of the two 30 inch mains, to prevent any chance of their settling in a similar manner and decided to have them rest securely on piling driven for this purpose.

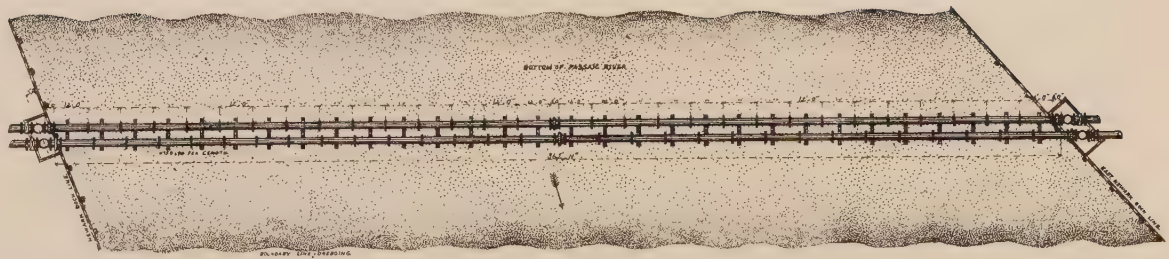
The United States Government, who through their Engineer Corps has control of the Passaic, issued a permit for the laying of these mains, stipulating, however, that at no point must they lay above a depth of 16 feet below mean low water mark, which means 23 feet 6 inches below string pieces of wharfs.

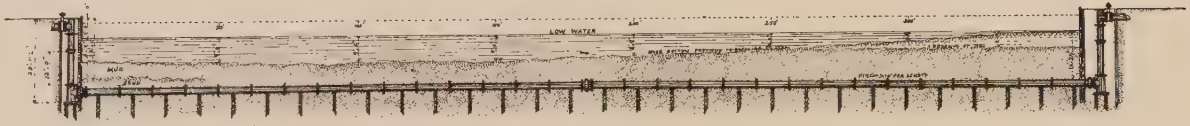
The channel at the Newark side of the river was, at the time of the carrying on of the work only 9 feet deep at low water. Since then the Government dredged it down to 12 and then to 16 feet depth without doing any harm to the mains. At the other shore the river bottom shoaled up to almost no depth at low tide. Thus a great deal of dredging became necessary, which formed a large percentage of the cost of the work.

A ditch of sufficient width and depth was thus dredged out. The bottom of the stream as far as we went was entirely made up of strata of grey sand of varying degrees of fineness.

Behind the bulkheads on either shore we constructed well holes by driving close jointed yellow pine sheath piling enclosing spaces 12 feet long by 8 feet wide. The mud and sand within these enclosures was then removed by dredging, pumping and actual digging by divers. It was difficult work, some


CROSS SECTION


BOTTOM OF PASSAIC RIVER
PLAN


LOW WATER
MUD
SECTIONAL ELEVATION

of the strata of sand and gravel being so hard as to deviate the sheathing from a plumb line while being driven and then again the quicksand at the bottom of the wells boiled up so as to endanger nearby structures.

In those wells we drove eight piles, built platforms on same and on these platforms rested the four drip pots, two in each well. The bottoms of these drip pots are 29 ft. 10 in. below wharf levels.

From the drip pots 30 inch stand pipes rise to the surface and from their flanged side outlets start the two lines of mains. We laid flange pipe throughout, each line being composed of 30 12 feet lengths, with three short pieces made of two flanged ends with a ball and socket joint between them. We placed in each line one of these flexible joints next to each pot and one at a summit in the center of the river. We were thus enabled to give the pipes a regular pitch of one-half inch per length from this central summit towards the pot.

After dredging and before laying the mains we drove a pair of piles for each pair of 12 feet length of pipes or altogether sixty piles. Each pair of piles was cut off under water according to our measurements and capped cross wise with 10 in. by 10 in. yellow pine timbers, 8 feet long. On these caps timbers the mains rest, held in place by wedges.

The pipes weigh 4,766 lbs. each, have extra heavy flanges and are held together by 24, 7/8 in. bolts. We jointed three pipes together on deck of floating derrick and then lowered them into position. The diver made the joints with the pipes already laid. We first intended to use mill board gaskets for this purpose but found that they softened too much under water before joint could be made and substituted thin sheet lead, heavily coated with red lead. Eventually we used these lead gaskets on all the joints made above or below water, so as to have a chance to do a little caulking, should there be any leakage.

We hardly hoped that the pipe lines would be absolutely tight and stipulated in the contract that after being pumped out they should not leak over 10 gallons in 24 hours, which

leakage should then be stopped by caulking from the inside.

As a matter of fact the pipes were tight right from the start and when a year ago the up stream pipe was taken into use—which up to that time had lain idle for nearly four years —it was found that the pots were dry.

The cost of the work summed up as follows:—

30 in. flange pipes, drip pots and flexible joints....	$5,225.95
Other special castings	601.81
Bolts, washers, pig, sheet and red lead, mill board and sundries	379.52
Pay-roll and engineering charges	488.39
Amount of contract for piling, dredging and laying of pipes	15,152.40
Total	$21,848.07

which is $25.35 per foot of pipe laid, standpipes and drip pots included.

THE PRESIDENT: I assume that as the author is not present, there will be no discussion. I think we should pass a vote of thanks to Mr. Strecker for his paper.

A vote of thanks was duly carried.

THE PRESIDENT: The next paper is

A REVIEW OF RECENT DECISIONS OF PUBLIC SERVICE COMMISSIONS WHICH AFFECT GAS COMPANIES.

BY MR. A. E. FORSTALL.

MR. A. E. FORSTALL: Mr. President and gentlemen of the Association, before starting to read the paper I want to make a slight modification of one of the statements in it. In reference to the issue of securities—the statement is made that one of the commissions has held that it cannot authorize the issue of securities for the reimbursement of the treasury of a company for moneys taken from the treasury for construction purposes. That is true; there was such a decision, but since writing the paper I have been informed that at the instance of the commission which rendered that decision, the law has now been changed, so that it now provides that securities may be issued "For the Reimbursement of the moneys actually

expended from income or from any other moneys of the treasury of the corporation not secured or obtained from the issue of stocks, bonds, notes or other evidences of indebtedness. * * * provided * * * that in the opinion of the commission the money, property or labor to be procured or paid for by the issue of such stocks, bonds, notes or other evidences of indebtedness is reasonably required for the purposes specified in the order of the commission * * and that such purposes are not in whole or in part reasonably chargeable to operating expenses or to income." That changes the status of the law considerably, you see, and destroys the point of that decision.

REVIEW OF RECENT DECISIONS OF PUBLIC SERVICE COMMISSIONS WHICH AFFECT GAS COMPANIES.

The regulation by State Commissions of gas companies, in common with all other companies furnishing service to the public, has apparently become an established practice in the United States since during the last five or six years such Commissions have been created in Vermont, New York, New Jersey, Maryland, South Carolina, Georgia and Wisconsin, while Massachusetts has had one since 1885.

Therefore, however much opinions may differ in regard to the merits of this method of regulation, a knowledge of the principles enunciated in the decisions of the more important Commissions is important and it is advisable to study these decisions in order to obtain this knowledge. The decisions of some of these Commissions, that in Massachusetts for instance, contain little outside of the formal order in the case under consideration and consequently give practically no indication of the governing principles which were followed in reaching the decision. Those of other Commissions, however, notably of the two in New York State and that in Wisconsin, give a full statement of these governing principles and the way in which they are thought to apply to the case in point, and therefore, the decisions of these commissions are the most worthy of study.

The cases coming from Public Service Commissions can be divided into four general classes as follows:—

Applications for permission to exercise franchises.

Applications for permission to issue securities.

Complaints as to rates charged.

Questions as to the quality of service.

Applications for permission to exercise franchises are more or less perfunctory, except when the franchise is one under which it is proposed to establish a company which will compete with an existing company already supplying the service in question. Since the same principles apply to both kinds of service, decisions of this class which concern electric light companies apply also to gas companies. Such decisions have been made by both of the Commissions in New York State.

The case which involved the largest interests came before the Commission for the First District. This, while in form an application for authority to issue securities, amounted really to an application for permission to distribute electricity over the whole of the Borough of Manhattan under a franchise which had been in existence for some time but had never been taken advantage of except in a very small way. The Commission decided that since the applicant had been supplying only one customer, in whose building its plant was located, it had really not exercised its franchise prior to the passage of the Public Service Commission law and that, therefore, it could not exercise this franchise without obtaining a certificate from the Commission authorizing it to begin work. This permission the Commission refused to grant because it considered that competition in the electric business in the Borough of Manhattan would not be for the benefit of the community, which could be better and more economically served by a single company provided this company was properly controlled as was the case with the Public Service Commission in existence. While other reasons were given for the denial of the application the principal ones were as follows:

"The applicant has not proved that the existing companies are not properly conserving the public interest and conven-

ience and that it would be to the advantage of the community to have a new company authorized to enter the field.

"If a competing company were allowed to begin operation, it is not likely that it would continue to operate independently for any considerable period.

"Competition would cause inconvenience and expense to the public, would cause duplication of plant, would lead to waste and ultimately be urged as a reason why rates should not be reduced to consumers.

"Practically all of the advantages claimed by the applicant as to the probable results of competition can be secured through the powers of the Commission, and until it has been demonstrated that these are ineffective, it would be unwise to adopt a method which has proved to be ineffective in the past."

It is interesting to note in connection with this decision that upon appeal to the courts it has been set aside, but this setting aside was upon the ground that the franchise had been exercised before the passage of the Public Service Commission law and, therefore, the company did not have to obtain permission for its exercise from the Commission. The court decision does not seem to affect the right of the Commission to prevent competition in cases which properly come under its jurisdiction and it is probable that the Commission will take the same ground should any such cases arise in the future.

Several cases of this kind have been decided by the Commission for the Second District of the State of New York. In one of these cases, that of an application for permission to build a plant and distribute electricity in a district the greater part of which was already supplied with electricity by an existing company, the Commission granted the desired permission. It was expressly stated in the decision, however, that the circumstances here were peculiar in that the service given by the old company had been so poor that this company was not in a position to claim any immunity from competition and that the community would be benefited by the

establishment of the new company, although the Commission still held that under ordinary circumstances such competition should not be allowed. This decision should serve as a warning to existing companies that if the service furnished by them is continuously below standard the Commission might look favorably upon a proposition to set up competition in their districts. It may be noted here that the competition permitted in this case has not actually materialized since so far the new company does not seem to have been able to secure the money with which to build its plant and commence operations.

In another case, that of an application for permission to begin construction and exercise franchises in a territory covering which another company already had a franchise for the supply of electricity, the Commission also granted the application. The reasons given for this decision were that, although the existing company held this franchise covering the territory and was supplying electricity in adjoining territory and gas in that in question, it had not yet entered the latter to any material extent for the supply of electricity, and consequently had no investment therein that would be endangered by competition and that since the inhabitants of the communities in question had a strong feeling against this company and wished to patronize the applying company, the Commission was not warranted in refusing the application, although it would advise that, in its judgment, the communities could obtain the cheapest possible supply of electricity by arranging to take it from the existing and larger company instead of starting up a smaller one. According to this decision the mere possession of a franchise in certain territory which has not yet been occupied will not be allowed by the Commission as a reason for keeping out a new company in cases where the company owning the existing franchise has not the good will of the inhabitants of the territory.

Although the decisions referred to above give permission to companies to exercise competing franchises under special conditions the same commission has in two other decisions taken

the stand that normally, competition in the supply of gas and electricity is not beneficial to the community and should not be allowed.

In a decision permitting the consolidation of electric companies which had been in competition it was stated that full and free competition between two companies engaged in the distribution of gas or electricity for light and power cannot be expected to prevail permanently, but as shown by experience the companies generally find it to their interest to either agree on prices or a division of the territory or to combine. Better service with the use of less capital can, as a general rule, be given by one corporation than by several. The existence of more than one corporation leads to duplication of plants and distributing systems, to unnecessary tearing up of pavements and to administrative expenses in excess of those which a single company would have to meet and while better service and lower prices may be obtained during short periods because of temporary competition, after the almost inevitable consolidation the service often becomes poor and prices are raised in order to secure returns on unnecessary capital invested in duplicated plants.

In a more recent decision upon an application of various individuals for permission to form a company and undertake the supply of gas and electricity and the operation of an electric street railway in a small city in competition with an existing company which, after having given very poor service for several years, had finally gone into the hands of a receiver and through reorganization proceedings, the Commission denied the application, in spite of the fact that the existing company before reorganization had failed signally to give satisfactory service. The reason given for this denial was that the reorganized company, which was starting with a low capitalization had a legal right to operate the properties already in existence and the presumption was that it would give good service, and that the entrance of a new corporation into the field would be beyond question merely the first step in a conflict that would end either in the absorption by one

company of the other with an increase in capital on account of such absorption or in the destruction of capital values of one or the other company for which there would be no justification under the existing conditions.

The cases in which these decisions have been given are for the First District, that of the application of the Long Acre Electric Light and Power Company for permission to issue securities, and for the Second District, the applications of the Citizens' Electric Service Company of Bath, of the Islip Electric Light Company and of certain persons in Port Jervis for permission to exercise competing franchises, and that of the application of the Lockport Electric Companies for permission to consolidate and issue bonds.

As far as I know the Railroad Commission of Wisconsin has not as yet had to pass directly upon this question of permitting the exercise of a competing franchise. The matter, however, is referred to in a decision rendered upon the application of a company formed by the consolidation of several competing companies, for permission to increase its rates which, as a result of the competition, had been low. This permission to increase rates was granted and in the decision the reasons for the avoidance of competition are stated in practically the terms employed by the Commission for the Second District of New York.

Permission to exercise competing franchises has been steadily refused by the Gas and Electric Commission in Massachusetts.

It would seem, therefore, that in spite of the two exceptional decisions of the Public Service Commission for the Second District of the State of New York, an existing gas company which is supplying, and furnishing good service in, a given territory will under Commission regulation be free from any danger of the starting of a competing company.

Quite a number of cases of the second class, involving applications for permission to issue securities, have been decided by the Commissions for both the First and Second Districts of New York State. The decisions in these cases

seem to have been based upon the following general principles.

It must be clearly shown by the applicant that the proceeds of the sale of the securities to be issued are to be applied to one or other of the purposes named in the Public Service Commission law. These purposes in the case of a gas company are the acquisition of property, the construction, completion, extension or improvement of its plant or distributing system, the improvement or maintenance of its service and the discharge or lawful refunding of its obligations.

The property to be acquired must be either directly useful for the business of the company or of such a nature that it is probable that it will be useful within a reasonable time.

In the case of new companies and of companies formed by the reorganization of bankrupt companies, securities will not be authorized to be issued to an amount in excess of the present value of the tangible property and of such intangible property as constitutes a right to demand and receive, or otherwise enjoy the possession of property or to an amount upon which there is no possibility of paying interest. In the case of an old company applying for the issue of securities to pay for specified extensions and improvements, the Second District Commission ruled that as long as the proceeds of the securities it authorized were properly applied it was not concerned with the previously outstanding capitalization.

In passing upon cases in this class the Commissions have inquired very carefully into the purposes to which the proceeds of the sale of securities were to be applied, the value of the property acquired by the company resulting from a reorganization and the cost of the plant to be constructed by a new company, and, when it seemed necessary, have investigated the financial history of the applicant. The decisions rendered name specifically as not being proper subjects for the issue of securities:

The payment of stock dividends.

The reimbursement of the treasury of the company for

money previously expended, even though this money has been expended for the acquisition of property.

The replacing of old mains by new ones.

Excessive commissions for the replacing of one issue of bonds by another.

Temporary operating deficits.

It was held, however, that operating deficits incurred when the company first began business and other development charges might be proper subjects for capitalization.

It was also held that a steam railway could not issue bonds secured by its steam railroad property to cover the purchase of coal lands and of an electric railroad which did not serve as a feeder to the steam road, because these expenditures were not for property useful in the business of the company. On the other hand it was held that an electric company could issue securities to pay for the improvement of a pulp mill which had been bought for the purposes of securing water power that would ultimately be needed for the generation of electricity.

The Second District Commission has also refused permission to issue certain securities when in its opinion the money required for the purposes specified could be raised in other ways, which would not impose as heavy a continuing interest charge upon the property as would be done by the issue of the securities applied for.

Under the decisions as long as the expenditure of the money derived from the sale of the securities authorized is subject to audit by the Commission, it is not necessary to divide the total expenditure into particular items.

The decisions in which these principles have been set forth are, for the First District, the Third Avenue Railway reorganization applications and the applications of the Bronx Gas and Electric Company and the Kings County Electric Light and Power Company for permission to issue bonds, and for the Second District, the applications of the Newburgh Light, Heat and Power Company, the Erie Railroad Company the Babylon Electric Light Company, the Watertown Light

and Power Company, the Rochester, Corning and Elmira Traction Company, the Long Island Railroad Company, the Lehigh and Hudson River Railway and the Delaware and Hudson Company for permission to issue bonds and stock.

The Railroad Commission of Wisconsin has not as complete control of the issue of securities as is possessed by the Commissions in New York State. In fact, according to the only one of the Wisconsin decisions on this subject which I have on file, the Commission itself held that under the law it was required to authorize any issue of securities as long as the applicant had followed the proper procedure and had shown that the purposes to which the proceeds of the securities were to be applied were legal and the amount reasonably necessary for these purposes. The Commission stated that under these conditions it had no power to refuse authorization for new issues even though it was thought that the existing capitalization was excessive.

No important decisions involving the adjustment of rates have been rendered by the New York State Commissions. That for the First District has had no cases of this kind, while that for the Second has only decided formally one case in which the conditions were such that the refusal to reduce rates could be arrived at without any extensive examination or analysis. The Railroad Commission of Wisconsin, nas, however, handed down several decisions in cases where complaints had been filed against the rates charged by water, gas and electric light companies and two of these cases dealt particularly with the rates charged for gas.

In these decisions the Commission states that in order to be able to render a fair, intelligent judgment upon the matter of rates it is necessary to determine the fair value of the property devoted to public use, the rate of return upon this value that should be allowed to the investor and to the operator, the gross earnings that can be secured with any given rates, and the reasonable cost of operation, this cost including both a proper charge for the depreciation which occurs in spite of

normal expenditures for maintenance and an adequate return on the value of the property.

While the first decision handed down in which the method adopted in arriving at the fair value of the property is fully explained was in the case of a water company, the principles set forth in the summary of this decision are general ones that apply to gas and electric companies as well as to water companies. According to this summary the value allowed should fairly represent the legitimate and necessary costs of constructing the plant and building up the business and should be arrived at by a method which would make the result subject to the fewest possible fluctuations. The most equitable valuation of the physical plant would seem to be represented by the original cost and the cost of reproduction new. The original cost, after the elimination or readjustment of any abnormal or irrelevant items, should represent very closely the legitimate, necessary and, therefore, equitable cost of the physical plant and should closely correspond to the cost of reproduction new especially if the estimate of the latter is carefully made and is based upon normal conditions and prices of materials and labor. The cost of reproduction new less the depreciation, that is the present value of the plant, throws considerable light upon "the equitable cost-value" of the plant and may be of almost controlling importance where, with earnings taken as a whole sufficient to cover operating expenses, depreciation and reasonable returns to the investors and to those who carry on the business, the amounts which should have been used to care for depreciation have been distributed among the stockholders or the owners. This present value will, also, be of the greatest importance in connection with condemnation proceedings and when a plant is taken over by a municipality.

Since prices of materials and labor are subject to considerable fluctuation from time to time the values of the physical plant determined upon the basis of the prices obtaining at the date

of an appraisal are neither as equitable nor as satisfactory as those based upon average or normal prices.

The most equitable valuation of the business of a plant is that determined from the losses during the earlier years of operation, or in other words the deficits during the development period, when gross earnings were not sufficient to cover legitimate operating expenses including depreciation and reasonable returns in the form of interest and profits. These deficits represent the cost of the business in much the same way that the cost of construction represents that of the physical plant.

This cost of building up the business may be written off and charged to operating expenses instead of being included as part of the investment, but such treatment causes this part of the cost to be carried by a small part, only, of the consumers instead of being distributed equitably over all of them, while this charging off must be done at a time when it is important for the development of the business that prices be as low as is consistent with the earning of a fair return on the value of the property. It is, therefore, better to consider this cost of building up the business as part of the permanent investment.

No values should be allowed for franchises above their actual cost nor for good will or other things of similar character. Such values depend upon the value based upon earnings being in excess of the proper valuation and earnings cannot be a fair basis for a valuation upon which rates are to be based.

The earnings from operation, the operating expenses and the assets and liabilities are of great importance and should be determined and fully analyzed before any valuation is reached in cases involving the rates and services of public utilities.

In a more recent case, in which the rates for gas were involved, the summary of the decision states that in arriving at the values adopted, the Commission gave consideration to the cost of reproduction new, the present value, the original cost and book value to present owners, the capitalization, the

earning value on a basis of 7.5 per cent. for the gas property and 8 per cent. for the electric property and to various other factors that are more or less closely related to the question of valuation.

Although all of these various factors have been considered in each of the cases so far decided, the controlling ones in arriving at the value of physical plant seem to have been the cost of the reproduction new of this plant and its present value, the values arrived at in other ways being used merely to check those derived from these controlling considerations.

To arrive at the cost of reproduction new a complete inventory of the property is made by the engineering staff of the Commission in coöperation with the representatives of the company. The cost of each item of fixed plant shown by the inventory is estimated, as is also that of placing each item in position, and the sum of these various costs is taken. To this sum 12 per cent. is added to cover organization expenses, engineering, interest during construction, insurance and contingencies. This gives the estimated cost of reproduction new of the fixed plant and to it is added that of the stores and supplies on hand.

The value reached in this way by the engineering staff is given out as a tentative valuation and is subject to change, if conferences which are held between members of the staff and engineering representatives of both of the parties to the action convince the staff that certain items of this tentative valuation are not correct. The valuation which is decided upon by the staff after these conferences is then submitted to the Commission and parts of it are generally made the subject of expert testimony during the formal hearing of the case. It is, however, usually accepted by the Commission as being correct.

The amount to be deducted for depreciation in order to arrive at the present value of the plant is determined by fixing a scrap value and a length of life for each item of the inventory and taking the depreciation as being the amount

which would have been built up during the age of this item by the annual installments and accrued interest required to make up, on a 4 per cent. sinking fund basis, during the whole estimated life of the item, its total depreciable value, that is its cost new less its scrap value. This determination, which really fixes the present value by the age of the item irrespective of its condition, is supposed to be modified to make the condition a factor by means of certain corrections which are applied in case the inspection of the plant shows the general conditions of maintenance to be poor. In the cases so far decided, however, few, if any, corrections of this kind have been made.

In addition to the scrap value there is also fixed a minimum service value below which the present value is never set as long as the machine or piece of apparatus is in active operation, even though the amount of depreciation determined as described above should be greater than the difference between the cost of reproduction new and this minimum service value.

To the cost of reproduction new and to the present value of the physical plant there is added the item of working capital, exclusive of stores and supplies, which item is fixed by the Commission to suit the circumstances of each case as shown not only by the evidence introduced during the hearing but also by the information obtained by the Commission from its examination of the accounts of the company.

To obtain the full value of the property there is still to be added the value as a going concern which, as previously stated, the Commission considers to be the cost of building up the business as measured by the deficits during the development period. This cost is determined by the Commission principally from the information obtained through its examination of the books of the company as to the original cost of the plant, and that of all additions, and the operating expenses and income. The information so obtained is employed to build up a table showing year by year for the period chosen, which is either the total life of the plant or the time during

which it has been controlled by the present owners, the value of the plant upon which earnings are to be allowed at the beginning of each year, the additions made to the property during the year, the increase in land value, if any, the proper charge for depreciation, if no, or an insufficient, allowance for this item has been made in the operating expenses, the interest on the initial value computed at the rate adopted as fair, the total of these items, the net earnings, and the difference between the total named above and the net earnings, this difference being taken as the value of the property upon which a return should be allowed at the end of the year.

If the final value obtained in this way is less than the cost of reproduction new this fact is taken as showing that the total value to be allowed the property is not greater than the actual investment in the plant or, in other words, that the development of the business has not actually cost the company anything because any deficits incurred in earlier years have been made up in later ones. If, on the other hand, this final value is greater than the cost of reproduction new the difference gives an indication of what the cost of developing the business has been and is of assistance in determining what should be added to the cost of reproduction new to determine the fair value upon which a return should be allowed.

The relation between the result given by this method of computation and the cost of reproduction has not been the same in any two cases. In one the final value obtained was larger than the cost of reproduction new and the Commission allowed a value that was larger than this cost but was not as large as the value determined by the computation. In another case, which was one involving rates for gas, the final value obtained by the computation was lower than the cost of reproduction new and the commission allowed a value practically equal to the cost of reproduction new including working capital.

In this case the difference between the present value of the physical plant, including working capital, as fixed by the Commission, and the value allowed was about 19 per cent. of the

former value and slightly over half of the amount claimed by the witnesses for the company as the value of the gas property as a going concern over and above the physical value.

The question of the proper rate of return upon the value of the property arrived at as described above, is discussed by the Commission as follows: The return is divided into two parts, interest on the money employed and profit to those who are carrying on the business. This distinction should be made even though the same people both furnish the money employed in the business and manage the property. It is necessary to allow interest because capital cannot be secured without paying for it any more than can be the materials employed in the construction and operation of the plant and interest is the method by which capital is paid for. A certain amount of profit, in addition to the normal rate of interest, must also be allowed because, if it were not, there would be no incentive to any one to undertake the business of supplying gas, or similar service, to a community since this business involves cares and risks beyond those involved in the mere investing of money in such securities as the bonds of public service companies.

The rate of interest that should be allowed is determined from the facts shown by an examination into the history of the company involved in each case. In the cases so far decided the rate, which this examination into the history of the company, has shown to be necessary to secure the capital required, has been 6 per cent. This has been either the rate at which bonds have been floated at par or that which the company actually pays upon the money derived from the sale at a discount of bonds bearing a lower rate of interest.

The profits to be allowed to the operators are stated to depend upon the amount of care and intelligence required in order to make the business successful, and upon the risks involved in carrying on the business. The amount of care and intelligence which are required in the case of the management of water companies, gas companies and electric companies are not considered as great as those required in the manage-

ment of a mercantile or ordinary manufacturing business. This is because the commodities in which such companies deal are to a certain extent necessities and can in any given town be secured only from one company, while the commodities dealt in by a mercantile or ordinary manufacturing company are not necessities and in most cases there is active competition by reason of which any would be user of any article may secure it from two or more different concerns. In view of these considerations the Commission has fixed the rate of profit in the case of a water company at 1 per cent. and in the case of a gas company at 1½ per cent. making the total rate of return upon the value of the property 7 per cent. for the water company and 7½ per cent. for the gas company. It is stated that the same conditions are not found in every case and that the rates fixed are not general ones but merely those which were found to be proper in the particular cases decided.

I think it probable, however, that the conditions in regard to these points would not vary very much throughout the State of Wisconsin and that the rates of return fixed may be taken as a fair indication of what the action of the Commission would be in other cases, except possibly for the very large cities.

In order to arrive at the total cost of service the proper charge for depreciation must be added to the total obtained by adding together the operating expenses and the amount required to yield the rate of return upon the value which has been allowed. The extent of the depreciation suffered by the plant which was used in determining its present value was figured on a 4 per cent. sinking fund basis but in arriving at the annual charge for depreciation, the Commission has apparently compromised between this and the straight line method of figuring this charge and has adopted in the most important gas case decided a 2 per cent. sinking fund basis which, on the average life of 30.4 years, results in an annual charge that is only slightly lower than it would have been on the straight line method.

For the electric plant belonging to the same company which had an average life of about 17.5 years, the charge for depreciation was figured on the straight line basis.

The sum of the operating expenses, the annual charge for depreciation and the total amount produced by applying the rate of return to the value of the property is the amount of money which the company should earn annually. In determining the rates to be charged so that the earnings will be equal to this amount the Commission has recognized the fact that the operating expenses of a gas company should be divided into at least two classes of costs, that is those which bear a direct relation to the number of the consumers or meters and may be called "consumers' expense" and those which vary with the number of cubic feet of gas used and may be called "output expense." It also recognizes that there might be further division of the costs into a third class, called "demand expenses" which would vary with the amount of the maximum demand for gas made by the consumer. It was considered, however, that in the case under consideration this class of "demand expenses" was unimportant and, therefore, could be included with the "consumer's expenses."

The operating expenses as shown by the books of this particular company after some slight changes made by the Commission were divided between the two classes as follows:

All station or manufacturing costs were considered as "output expense." Street main maintenance was apportioned one-third as "consumers' expense" and two thirds as "output expense," while service maintenance was classed entirely as "consumers' expense." Street Department expense was divided equally between the two classes as was also gratuitous work. Meter maintenance, meter department expense, setting and removing meters and collection expense were placed entirely to "consumers' expense." General, new business and extraordinary expenses, and bad debts were considered as overhead charges and apportioned between the classes according to the relation that was found to obtain between the total of the items that could be directly distributed, and since "consumers' ex-

pense" formed 18.42 per cent. of the total amount of the items directly apportioned to both consumers' and output expenses these overhead changes were apportioned 18.42 per cent. to consumers' and 81.58 per cent. to output expense.

Depreciation on the manufacturing plant was charged entirely to "output expense;" that on mains was charged one-third to "consumers' and two-thirds to output expense," and that for services and meters entirely to "consumers' expense." Interest, profit and taxes were apportioned between the various parts of the system and then divided between "consumers' and output expense" in the same manner as was the depreciation charge.

After making these apportionments it was found that the "consumers' expense" was 22.33 per cent. and the "output expense" 77.67 per cent. of the total cost of service during the last year of the period considered.

The "consumers' expense" was divided by the number of meters set rather than by the number of consumers served, it being considered that this cost varied rather with the number of meters than with the number of consumers. As there was very little difference between the number of meters set and the number of consumers the result would not have been materially different had the apportionment been according to the number of consumers.

When the cost of service was analyzed in this way it was found that the "consumers' expense" amounted to practically $0.52 per meter per month and the "output expense" to practically $0.79 per thousand cubic feet. With these figures, the costs of supplying consumers varied, according to the consumption per month as shown in the table given on page 19.

Although, in a case previously decided, the Commission, following the same line of reasoning as to the division of cost between "consumers' expense" and "output expense," had permitted a gas company to make a rate of 25 cents per month per meter with a charge of $1.00 per thousand for the gas consumed, the meter charge being imposed irrespective of con-

Cu. ft. per month		Consumer cost	Output cost $0.7924 per M	Total cost	Total cost per M cu. ft.
1	M	0.517	$0.792	$1.310	$1.310
1.5	"	"	1.189	1.706	1.137
2	"	"	1.585	2.102	1.051
3	"	"	2.377	2.894	0.965
4	"	"	3.170	3.687	0.922
5	"	"	3.962	4.479	0.895
10	"	"	7.924	8.441	0.844
25	"	"	19.810	20.327	0.813
50	"	"	39.620	40.137	0.803
100	"	"	79.240	79.757	0.798
250	"	"	198.100	198.617	0.794
500	"	"	396.200	396.717	0.793
1,000	"	"	792.400	792.917	0.793

sumption, in the later case, for some reason which is not clearly explained in the decision, the logic of the argument was not strictly followed in fixing the rate.

If each meter set represents a cost to the company of $0.52 per month, irrespective of any sale of gas through the meter, the company should receive from each meter $0.52 per month and in addition should be paid at the proper rate per thousand for the gas consumed through this meter. It is possible that the Commission feared public outcry if a rate were applied which would result in increasing the cost of service to probably 50 per cent. of the consumers even though this 50 per cent. consumed only a comparatively small portion of the total sales of gas. Whatever the reason, no fixed charge per month irrespective of consumption was allowed in the rate as fixed, although a minimum charge of $0.50 per month was allowed, this to include all the gas consumed until the cost of this gas at the price per thousand fixed in the decision exceeded 50 cents. The net rates per thousand cubic feet were fixed at $1.15 for the first two thousand cubic feet per month, $1.05 for the next three thousand cubic feet per month, and $0.90

for all over five thousand cubic feet per month. The company was also allowed to make a gross rate in each case $0.10 per thousand higher than the net rate, the $0.10 being deducted in case the bill was promptly paid.

From the analysis of the costs given in the table previously inserted it will be seen that the net prices fixed per month result in the paying of less than their fair share of the cost by the consumers of less than fourteen hundred cubic feet per month and the paying of the consumers of over five thousand cubic feet per month of more than their share of the total expenses. As stated above the decision does not explain clearly why the Commission fixed rates which thus dicriminated in favor of part of the consumers and against others.

It is interesting to note, however, how completely the reasoning of the Commission and the rates allowed bear out the contention of those managers of gas properties who have insisted that a uniform flat rate per thousand cubic feet of gas sold was not a fair and equitable method of charging.

The cases referred to are the application of the Manitowoc Gas Company for permission to change its rates and the complaints against the rates charged by the Antigo Water Co. and the Madison Gas and Electric Company.

The quality of the service supplied by gas companies has been made a subject of regulation by the Commissions in Massachusetts, the Second District of New York State, and Wisconsin. These regulations embrace in all the States the question of the amount of impurities to be allowed in the gas and the accuracy of the meters supplied for the purpose of measuring the gas sold to each consumer. Those in force in Massachusetts and the Second District of New York also fix the illuminating value of the gas to be supplied. In Wisconsin the regulations fix the calorific, but not the illuminating, value of the gas and also cover a subject not covered in the other States, that of the pressure at which gas shall be supplied to the consumer. The regulations on the items covered in all the States are shown in the following table.

Amount of impurity allowed in grains per 100 cu. ft. gas	Massachusetts	New York	Wisconsin
Ammonia	10	10	Not covered
Sulphuretted hydrogen	None	Trace	Trace
Total sulphur	30	20	30

The Massachusetts regulation as to illuminating value is that the gas shall be of 16 candle-power. That of the Second District of New York is that straight coal gas shall have a candle-power of 16, a mixture of coal gas and carbureted water gas one of 18, and straight carbureted water gas one of 20.

The calorific value provision in Wisconsin is that the gas tested within a one mile radius from the distribution center shall show a monthly average total heating value of not less than 600 B. t. u., with a minimum of not less than 550 B. t. u., per cubic foot. The regulation of the same State as to pressure is that the gas pressure as measured at meter inlets shall never be less than 1.5 inches, nor more than 6 inches, of water pressure and that the daily variation of pressure at the inlet of any one meter on the system shall never be greater than 100 per cent. of the minimum pressure.

In Wisconsin it is also a regulation that no gas company shall allow a gas meter to remain in service for a period longer than three years without checking it for accuracy and readjusting it if it is found to be inaccurate. In the First District of New York a gas meter is allowed to remain in use for seven years without being tested.

The Public Service Commissions law in New York and the corresponding law in Massachusetts require that all gas meters, whether new or after having been given major repairs, must be tested and stamped by the agents of the Commission before being set on a consumer's premises. There is no such regulation in force in Wisconsin.

The gas supplied by any company in the States mentioned being subject to regular tests, by which it is determined how the company is complying with the regulations, complaints as

to quality of service are settled directly by reference to the records of the commissions in each case and the fact that these records show substantial compliance with the regulations is taken as showing that the company is rendering good service.

The limits of space available in a paper of this character have made it impossible to do more than give a brief outline of the principles contained in the various decisions which have been reviewed. The decisions, themselves, give in full the reasoning by which the principles have been reached and it would be to the advantage of all the members of the Institute who are interested in the question of the relation of the community as a law making body to the operation of public utility companies, to obtain copies of these decisions and read them carefully.

THE PRESIDENT: Gentlemen, Mr. Forestall's resumè of the decisions of the Public Service Commissions is timely and interesting. Is there any discussion?

MR. R. M. SEARLE: The recent decisions of the public service commissions through the country illustrate the great advantage of dealing with the commission with the cards on the table. Each decision rendered shows a better appreciation of the necessity of proper funding for the public service corporations of all kind in this country. In a case where I was recently called in, in the west, the commission through ignorance was attempting to allow the funding of finances on a basis of the cost to reproduce new at the present market value. This particular company went in the market in the very prosperous times of a few years ago and bought immense quantities of materials at a high market rate, and the difference in the price paid for those materials and what they would cost today is some 33 per cent.; the commission allowed that for all of that expense a contingent fund should be set up and funded and amortized. In this particular property it made a difference of something over a million dollars. We must put our cards on the table, give them the truth, and educate ourselves as to the best methods of financing our companies. The new

method of financing is so different from the old that it is up to the men in charge of such companies to educate themselves along modern lines, if they propose to stay in the business. One commissioner told me personally that he was beginning to believe that in some cases rates would have to be raised in order to give the character of service they proposed to demand; that good service was the first requisite of a public service corporation and for good service they were entitled to proper remuneration; so that is encouraging. We have always given good service, and to give better service at a high market value for labor and materials—we should have a higher inducement for capital to go into such ventures. I have been at Albany during the last three sessions of the Legislature and have tried to make clear to the legislators the necessity for the provisions Mr. Forstall just read—the necessity of funding promotion expenses and a proportion of replacement costs. If we could fund a proportion of these costs, we could immediately improve our service and give a reduced rate. If we must come to general public service control, the recent decisions of commissioners indicate that they are going to allow us some funding of replacement promotion costs. They have already decided that if you and I form a company and have a hundred thousand dollars invested in promotion expenses and capitalization, then we are started. Now why isn't it good business, in order to give good service, to go on as fast as we can and increase the business and capitalize it a hundred thousand dollars a year, and spread this over a fifty year funding period and amortize it, thus giving past, present and future a low average rate? The average of the large companies in this country for fixed charges, that is capital charges, are about 25 per cent. of their gross receipts. See what that means on your rate if it could be properly funded over a long term of years, perhaps longer than fifty, and let the present and future consumers participate in a low average rate? I am going somewhat into the details of this because I want to insist that it is necessary for the manager and engineer when the occasion

arises to know something about how to tell the commission his troubles. They have hearings, gas and electric men go there, street railroad men and steam railroad men, and sit down, the commissioners plead with them to give them information, to state what their troubles are, but not a man gets up and says a word—apparently he has no troubles; then the commissioners go on and make decisions, which are to the best of their ability, all liable to honest errors of judgment. In speaking of calorific values, in a recent discussion with a commissioner the question was asked point blank "Do you believe in calorific value?" I said, "I believe in calorific value, but do not put on your statutes, or in your decisions, a value which no human being can give." "Well," he says, "what would be the proper calorific value for coal gas?" I said, "The proper calorific value for coal gas is all you can get out of the raw material as supplied by nature under usual working conditions. That is your obligation to your customers." A knowledge of just how to present such points clearly to a commission is most important.

THE PRESIDENT: One gentleman who was to discuss Mr. Forstall's paper is not present. He has sent in a written discussion and I will ask Mr. Brundage to read it.

Mr. Henry M. Brundage then read the following discussion by Mr. H. C. Abell:

I have read Mr. Forstall's review of Public Service Commission decisions affecting Gas Companies. He has analyzed the decisions in a very concise manner.

These decisions are of the utmost importance to Public Utility Companies of all classes, and the sooner the Companies become alive to the situation the better for all concerned.

Reading the decisions which allowed competitive concerns to come into a territory, it is probable that the competitive company would not have been allowed in, had the existing operating company taken interest enough to show the commission why the service could not be improved and extensions made.

The same applies to some extent to many of the cases which

have come up. Few, if any, of the cases have had the proper testimony to show what the rate of return should be, having left it to a large extent to the Commissions and courts to judge what that should be, or what rate of return would probably not be confiscatory. Much of the testimony has been given by engineers and operators, most of whom have not actually had any experience in financing. Their testimony is based on the experience gained from operating going concerns backed by financial men of reputation.

I was recently in a case where five of the leading bankers in the city testified to the rate of return on all the various businesses which they were interested in, both personally and as lenders of money, the standing an institution should have before they would consider them borrowers, and what proportion of the capital invested was earned in gross receipts each year.

It behooves the Utility Companies to present properly qualified witnesses and indisputable testimony before the Commissions and courts, otherwise the day of accounting will surely come when it will be impossible to raise money for extensions, etc.

Issuing of Securities: The Wisconsin Commission has the right to fix rates. The rates fix the value of the securities. If the existing capitalization of a Company should be excessive, the value of any additional securities on the whole property would be in relation to the total issue, new and old.

Rates: The opinions of Utility operators differ so widely, relative to form of rates and the subdivision of expenses, etc., that I should think Commissions would be bewildered by the voluminous testimony which does not always harmonize. For instance, the subdivision of the rate of return: Some operators think this item should be a fixed expense and put in as a fixed charge. If this item were so charged, when using a readiness to serve rate, there would be no incentive to develop the long hour users, as profits would be included in the fixed expense, and all the Company would receive for gas would be the output cost and no profit.

If a step rate should be instituted, the fixed expense would probably be obtained in the first three or four hours daily use of the demand and there would be no profit in developing additional use.

We ought to know more about this subject before we can advise and assist the Commissions.

One case cited in Mr. Forstall's paper refers to the cost of serving the consumers, and that each consumer should bear his cost to the Company, or at least a large portion of it, but the final rate given diverges from the preamble.

Valuation: As pointed out in one decision, it was thought the original cost and the reproduction cost should closely correspond.

I have analyzed several cases as far as the Company's records would show and I have been unable to find that the estimated replacement value checked with the actual cost. I have found the variations both ways.

For instance, in one case where a smaller company was operated by a holding company, I found that the estimated cost of replacement for a certain number of years was more than the cost shown by the books. The holding company had a first-class purchasing department, the work of construction was supervised by the holding company, the company was fortunate and had no accidents and carried no insurance. The holding company did not charge the small individual company for any time spent by the best of talent looking after its construction and expenses, neither did it charge up the purchasers at about what the cost would be to small individual company purchasing material as a unit.

To determine the physical replacement value of a company is not an easy matter. Some engineers apparently imagine that it is, and that after taking an inventory practically nothing should be allowed for omissions and contingencies.

It has been customary for Commissions and others to take an inventory of the plant in detail, obtain unit prices on the material and then estimate the cost of assembling the various parts, either in the plant, distribution system, or elsewhere,

and allow a percentage of this cost for engineering, contingencies, omissions, organization, insurance, etc., generally assuming that the percentage to be added would be less on this basis than it would be in the estimated cost of a new plant.

It appears to me that it would be as easy, if not easier to get the material required from a completed drawing with its details and specifications. To such an estimate 10 to 15 per cent. is generally added for contingencies and omissions alone. Engineering and the other items have to be added to this as a percentage.

In arriving at such a cost of a new plant engineers take prices of labor and material for a certain time in the past in order to prognosticate the cost to cover the period of the future that the construction of the plant will take.

My experience has been that most of the estimates for valuation purposes are based too much on theory and not on the results that we all actually encounter.

I think therefore the Utility Companies should gather as much of this information from actual cases to substantiate their claims.

One valuing staff of which I know was initially the valuing staff for a Tax Commissioner, and unfortunately for some of the railroad and utilities apparently imagined that the unit price should be less for taxation purposes, and endeavored to bring the values down to a minimum. An example of this is the percentage to be added for engineering, omissions, contingencies, organizations, insurance, interest while building, etc., which it was claimed should be only 10 per cent. We all know that such an amount is entirely inadequate. It was difficult for this staff to reconcile the two different statements on valuations. The various methods of endeavoring to obtain the amount in dollars of the going value of the concern by some assumed cost undoubtedly assist, but there are many other items which apparently are neglected, which I think should be more clearly explained.

For instance, to add or deduct the earnings which a concern has not made, or made over a certain specified amount which

a Commission considers fair, does not to my mind have much to do with the present value.

A company through good management and aggressiveness may have developed its property to an abnormal earning basis, several reductions having been made in rates during the period of operations, yet they are penalized on the valuation and not allowed any greater percentage of rate of return on the low valuation than is a concern which has not developed its business and has not made reductions in the cost of the service to the patrons.

Another method sometimes used, is to take the records of past gross earnings, operating expenses and history of the plant and city as an assistance to estimate the earnings and expenses for the next few years. It is then necessary to assume that the new plant will take a certain number of years to reach the earnings and expenses of the old plant, the same as it is assumed that it will take a certain length of time to construct the physical plant. The gross earnings and operating expenses are estimated each year for the new plant.

The credit to the old plant will be its earnings from the commencement of the new plant to the time when the earnings are equal; the debits will be the earnings of the new plant plus the difference in operating expenses, which expenses will be less with the new plant as its sales will be less.

The difference between the debits and credits for the period is the going value. The annual going values reduced by a proper rate of interest and footed up, give the present going value of the Company.

This method of arriving at going value, together with the method of arriving at the physical value, which is assumed to take a certain time element in the future to construct considers the value of localities, for it would be necessary to install the pipes under the paving, the paving would have to be taken up and put back, the present obstructions would have to be cleared, etc. All these items are of value to the present property, but I know of some cases where replacement value was supposedly taken, but the value of position or cost

of taking care of obstructions, removing and replacing pavements, were subtracted, because, it had been found that the Company had laid the pipe before the paving or other obstructions were in.

This appears to me to be retroactive, by giving an actual value less than it is now, and less than it would cost to replace. In the latter method of arriving at going value it is necessary to prognosticate the future development of the City and the development of the Utilities service. In a first class city with a high development of profitable consumers, and good prospects, it would take less time and less expense for the new company to obtain the gross earnings of the old company, yet from such a value standpoint the better city would figure up a less going value, although investors would pay more and the total valuation would be greater in the more progressive and growing city.

This method assumes the present developed uses for the service, and does not give credit for the past work and the past cost of developing its uses to the public.

Standards of Service: Commissions, Cities, and individuals have diversified opinions on the details of this subject.

It appears to me that each standard should be analyzed, and the cost of complying with the regulation and its benefit to the consumer obtained. For instance, whether a standard of luminosity or heat value should be used. If the users of 15 per cent. or less of the gas will not help themselves by purchasing modern appliances, why should there be a standard that would penalize the users of 85 per cent. of the gas?

I wanted to bring out more forcibly just a few of the very many questions which have to be settled, hoping that the companies, and each employee of the companies will gather as much important information as possible, and perhaps have it submitted to a Committee to be put in shape for specific and general use.

THE PRESIDENT: Are there any other gentlemen who would like to discuss Mr. Forstall's paper?

Mr. A. M. Barnes: I should like to ask Mr. Forstall two questions. He states that the decisions named, as not being proper subjects for the issue of securities, the replacing of old mains by new ones. I should like to ask Mr. Forstall if he intends to include therein the replacing of a small main by a larger main? If this company takes out a six inch main and puts in a twelve or twenty, whether he understands that the decisions do not allow any issue of additional securities for a larger main? He says the Second District Commission has also refused permission to issue certain securities for which in its opinion the money required for the purposes could be raised in other ways; whether we are to understand from that, that the Second District Commission insists bonds shall be issued if they can be floated at a less rate than the dividend which the company is then paying? If that is so, it seems to me to be a decided injustice to all the companies making gas, because the bonds become prior lines on the property and the interest upon the bonds must of course take precedence on the dividends on the stock.

The President: Mr. Forstall will reply to that question, Mr. Barnes. Are there any other gentlemen who wish to speak or discuss? If not, we will call upon Mr. Forstall to conclude the discussion.

Mr. A. E. Forstall: Mr. President, I wish to emphasize Mr. Searle's remarks in regard to the advisability of perfect frankness in dealing with public service commissions. I have one commission especially in mind, with which it seems to me that is a very paying policy. I have happened to be before that commission waiting for the commission to take up a case, while they were considering another case, and heard them compliment the people who had presented the case—upon the fullness and frankness with which they had stated their case, and that company got practically everything it wanted on that application. Speaking of the minimum calorific value of London gas, it is stated in the law that 450 B. t. u. is to be the minimum calorific value, but really the company is not penalized until it gets down to about 425, unless they fail on three

successive occasions. But it must be remembered in using that as a reference at any time that that is not really calorific value as understood in this country. The London regulation is that it shall be a so-called net calorific value, which is not recognized in this country as representing anything at all. It is merely an arbitrary figure which is dependent upon a certain way of determining the calorific value of the gas and the amount of condensed steam obtained from the consumption of a certain quantity of it, and does not represent anything that is substantial or real. Mr. Abell discussed the subject of the failure of companies to get the witnesses who were really qualified to testify as to the proper rate of return which should be allowed, his point being that engineers were not proper witnesses and that financiers should be obtained. I think his point is well taken, but in some cases with which I have been connected it has been found practically impossible to get the local financiers to testify. I do not know whether they were afraid to run up against public opinion or not, but they would not go on the stand; they seemed to be friendly to the company, but when they were asked whether they would testify they would not do it. Mr. Abell also made the point, which I think ought to be very carefully considered, that the valuations of physical property as made by the engineers of the Commission do not give sufficient weight to overhead and unforseen expenses. They are based almost entirely upon what you could obtain a certain piece of apparatus at the gate of the gas works or on the switch, and then could take a piece of apparatus from the car and into the works and mount it on a foundation and connect it up, but they do not allow enough for contingencies on that class of work. I think it is important that the companies should gather data as to those costs and have them in such a shape that they can present them to the commissions in a convincing manner. In regard to the valuation of a business as a going concern, it seems to me that in most of the methods that are used to arrive at the value of a business as a going concern, as distinguished from the value as a plant, exactly the same as the plant under consideration but without

any business they are based too much on the cost of obtaining the business. Now I do not see any reason why the value of real estate is not exactly analogous to the value of the business as a going concern, and I do not know of a single business in which the appreciation in the value of real estate has not been recognized, the value of the real estate at the time the appraisement is made, not what it cost the company to get it. In connection with the gas case here in New York, a very strong effort was made to have the decision made in that way, because some of the real estate was bought away back in 1820, and naturally the value in 1906 was somewhat larger than its value in 1820, but the courts did not decide that way. Now it seems to me that if that holds in real estate, it ought to hold in value as a going concern; it is the value of the business as it stands, not what it costs to get it, and it seems to me that there is no better evidence on that point than the same kind of evidence that is used in getting at the value of real estate—that of men who are accustomed to deal in properties and who are willing to pay so much more for a concern which has an established business of a certain character than they would pay for it if they had to build up the business themselves. I cannot see any escape from the logic of the comparison. Unfortunately a good many of the commissions have seen an escape from it. Mr. Abell also touched on a point which I treated of in a paper before the Institute last year; that is, of the justice of allowing a company which is better managed than usual to pay more than the ordinary rate of return. That can be gotten at by some sliding scale, the amount of the required dividends, which so far has been applied only in Boston as far as the United States is concerned, but it has been the custom in England for over thirty years. Another item of value that seems to me is also analagous to the real estate is the value of mains which are under pavement, even though those mains were put there before the pavement was laid and therefore they did not cost the company as much to put them there as they are worth now. That has been indirectly decided by the Supreme Court

of the United States, that the value of a street main is its value at it stands, but one commission at least has decided that paving placed over the main after the main was laid cannot be considered in arriving at value. With regard to the questions asked by Mr. Barnes, his first question was as to the replacing of old mains. I thought that would be understood to be the actual replacing of a main by another main of the same capacity; anything else is an extension or improvement of property, and as I understand the decision or ruling of the commission, it is that the company could not capitalize that portion of the cost which represented the cost of an old main, but I do not think there would be any objection to their capitalizing the difference of cost between the new main or the difference in value between the new main and the old main which was taken up and put out of commission. In regard to the issue of securities bearing a higher rate of interest than the commission thought could be obtained, there was the case of a gas company on the Hudson River that applied for permission to issue eight per cent. preferred stock. The commission refused the permission because they said that that would put a continuing obligation to pay the eight per cent. on the company and that they did not think that they could authorize any such continuing obligation even though at the time the application was made it was very difficult to get money except at a high rate of interest. The same company later made an application for permission to issue bonds maturing in ten years and bearing eight per cent., convertible into ordinary common stock of the company, and that was granted. The commission held that the eight per cent. interest was warranted by the conditions of the money market at the time and that as long as it did not continue over ten years, they were not saddling the community with a large interest charge, with a continuing interest charge. I think that answers Mr. Barnes' question.

Mr. Searle: I want to say something more on this question of being frank before public service commissions. The

moment a complaint is drafted, or a request made to appear, the manager rushes to the president and the president to his lawyer, and the lawyer goes down to tell the commission, which is eager for information, what he thinks the manager of the property wants. Now a lawyer cannot be frank to save his soul. It is not his training. He deals in technicalities, and worries the commission to death. I have never taken a lawyer with me for any purpose except when I am in court, and then I need him, because he is on the defensive; he is not going to be frank and you are not supposed to make out the other fellow's case. But in a case before a commission you know more in one minute and can tell it more frankly, fairly and plainly, and get justice quicker than any lawyer can. I urge that you personally leave your business and go there and tell the commission your troubles in plain English, what it means, what you are up against, how you are handicapped. A lawyer cannot describe it; he has no personal feeling in the matter, no salary at stake, no property at stake. The only thing he is concerned in is whether he wins or loses his fee. Now I am not "knocking" the lawyer; I am merely knocking the gas man that employs a lawyer to tell his tale when he doesn't know anything about it and does not know how to present it. I want to show you how easily and fairly it can be done. During the Legislature of last year at Albany a commissioner insisted upon discussing about fifteen paragraphs of alleged discriminatory matter in the bill, and we spent from eight o'clock until twenty minutes after three in the morning in the committee room taking them one at a time and debating them. This commissioner said to me across the table: "Isn't it rank discrimination to ask a deposit from one consumer and not from another?" I said, "If your wife came into my office, we would say 'Good morning, you don't have to sign anything but checks;' but some other woman might come into our office and we would make her sign every printed blank that we could get hands on, to ensure her paying her bills; if we did not, we would have to charge an average higher rate to the good consumer to cover this woman's bad debts. That is not

discrimination, that is managerial, and it is a function you have no right to participate in." He said, "All right, we will allow that." The next point was reading the meters. A complaint had come from a East Side Jew that he was discriminated against in the reading of his meter. That was put up to me. Imagine a lawyer answering these questions, a man that had never read meters; it takes a man who has read meters for a living to answer such questions. I said, "Let us assume that an orthodox Jew observes Saturday as the Sabbath and observing it religiously closes up, and that next door there is another Jew also closed up, but selling clothing at the back door. I will read the orthodox man's meter on Friday and I will break down the door to get to the other fellow's meter on Saturday, if we want to have respect for the other fellow's religion." He said "All right, we will allow that." Now I am begging you when you are called to a hearing, not to go to your president and say: "Will your attorney go down tomorrow?"

The President: In view of Mr. Searle's wind-up, I think we are to be congratulated that we are not lawyers. Yesterday afternoon, as I announced at the beginning of this session, Mr. DeHart read a paper, but the time was very short and there was no opportunity for discussion. Mr. Ellis of Providence, Rhode Island, wishes to say a few words on the installation of vertical retorts that he has just commenced to wrestle with.

Mr. John W. Ellis: Mr. President and fellow members of the American Gas Institute, I think the president has rather taken me by surprise. The question of discussing vertical retorts is far from my mind at the present time, but I am pleased to have the opportunity of answering the many requests which have been made of me by the members as to whether or not we would extend an invitation at this time to visit our new works. Before answering that directly, I will ask your indulgence to permit me to state briefly of what this plant consists. About three years ago the Providence Gas

Company was able to purchase a tract of land comprising about forty acres that was admirably adapted for the purpose. It was located about two and a half or three miles from the station. It has on one side fine water facilities, on the other end we have a very fine rail communication with the New Haven Railroad After considerable deliberation and an examination of all the systems and plants in vogue in this country, and from all the knowledge we could obtain abroad, we decided at last that it was best for us to install the Dessau system of vertical retorts. The contracts were made with the Didier-March Company, which is a branch of the Stettin Company of Germany, for two stacks of six benches each of ten retorts, four meters in length, consisting of two sections. The plant, however, is designed for an ultimate plant of four stacks. After personal observation abroad last summer, I was so much convinced of the desirability of vertical retorts, that I advised that we build another stack at once, and the contract was placed; so that we have three-fourths of the installation nearly finished at the present time. We have a complete coal gas plant from the discharging of vessels at the wharf to the station meter, and we have a plant which, when you visit us, I hope will impress you with one principle which I have endeavored to make pre-eminent, and that is, that in the details of the designs, the structures and all buildings, the one feature shall be permanency of construction. I have always adopted that theory in every public work which I have had the privilege of directing as the engineer of construction, for I believe in that way it is better to spend your money at once, even at a large capital cost, and reduce to a minimum the maintenance cost, and remove as far as possible that everlasting bugbear of depreciation, which will not enter into this plant, I hope, in the first few years of its operation. Ground was broken for this plant May 1st, 1909, and I had the pleasure on the 12th of this month to charge the first retort. One stack is in operation. We cannot give you any results, or any costs of operation, but I am pleased to extend to any members of the Institute an invitation to visit this plant even at the

present time, for I well know that none of you will view us with a critic's eye at this time. If any member who has the intention of visiting our plant will either signify to myself or to our engineer, Mr. Carroll Miller, his intention, we will endeavor to provide him with transportation to the plant, and we will also try to make his visit to Providence as profitable and pleasing as it is possible for us to do.

Mr. A. E. Forstall: In the absence of Dr. Humphreys to champion depreciation, I think I shall have to challenge the statement of Mr. Ellis, or his inference, that by spending money enough in getting massiveness and permanence in building or an apparatus, you can save depreciation. I do not see how you can. Depreciation does not consist entirely of the wearing out of a piece of apparatus; in fact, in my opinion that is one of the minor elements. Unless Mr. Ellis can certify, and can make people believe, in addition to certifying, that that kind of plant is going to last forever without being replaced by any other plant, even though it is in perfect condition, he has got to charge up depreciation against it right from the very start.

Mr. Ellis: I should like to say that I have had considerable experience, serving as a commissioner on a great many water plants where this bugbear of depreciation has entered largely into the question, and we have been obliged to allow a large amount of expert evidence to enter into the case, but when the final adjudication by the commission was taken up, a great deal of it had been considered as chaff. Now, I believe in spending, as I have said, a part of the money so as to remove as far as possible the question of depreciation, for I believe that there are a great many other things in gas management that worry a man much more than depreciation. Depreciation is a question more of business than it is of theoretical expert testimony, although I have been in both places, both as an expert and as an engineer.

The President: Gentlemen, we omitted to pass a vote of thanks to Mr. Forstall for his paper.

A vote of thanks to Mr. Forstall was carried.

THE PRESIDENT: We will also extend a vote of thanks to Mr. Ellis for his kind invitation to all the members to visit Providence.

A vote of thanks to Mr. Ellis was then carried.

THE PRESIDENT: The time has arrived for adjournment. We will now take a recess until 2:00 o'clock.

(Adjourned at 12:35 P. M.)

THURSDAY, OCTOBER 20, 1910.
AFTERNOON SESSION.

The session was called to order at 2:10.

THE PRESIDENT: We will start the afternoon session with a paper entitled

APPARATUS DESIGNED FOR REMOTE CONTROL OF DISTRICT PRESSURE.

BY MR. J. S. KENNEDY.

Mr. Kennedy then read his paper, which was illustrated with stereopticon slides.

APPARATUS DESIGNED FOR REMOTE CONTROL OF DISTRICT PRESSURE.

Modern gas consuming appliances are mostly of the atmospheric or bunsen burner type, in which the necessary air is injected and mixed with the gas before it reaches the zone of combustion. As the injection of air is caused by the pressure of the gas, the proper operation of all such appliances necessarily depends to a large extent on the gas pressure and its uniformity.

In the distribution of gas to consumers it follows therefore that next to quality, the most important factor contributing to efficient service is a sufficient street main pressure maintained uniformly.

This condition is entirely ideal and is usually impossible in practice. It is not possible to maintain the same pressure throughout the entire district at all times, but it is possible to

maintain a fairly uniform pressure at most consumers services

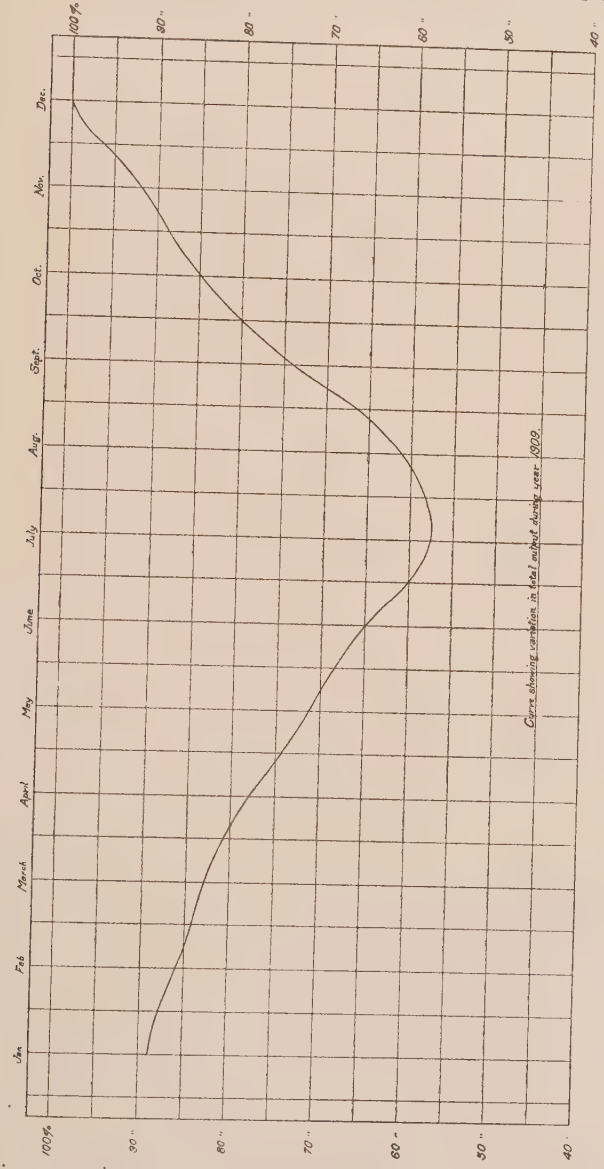


Plate II.

which is more important to the consumer than the amount or

value of the pressure, provided the latter is sufficient to properly operate his appliances.

In most cities, the conditions which render absolute uniformity impossible are variations in elevation, position, or distance from point of supply, irregularities in the quantity of gas consumed and times of consumption, and sometimes insufficient pipe capacity and inefficient pressure controlling apparatus. In some localities topographical elevations vary several hundred feet and often include areas in which large districts differ materially in level from adjacent districts. This condition is further aggravated by the height of buildings, business and dwelling, in which gas is consumed in large and irregular quantities. However, if the location of the holders and feeder mains bring the consumers within reasonable pipe distance from points of supply and serve them through mains of ample capacity the difficulties are lessened.

The peak load variation, however, is usually very marked and assumed characteristic peak loads are shown graphically on plates II, III, IV and V. Plate II illustrates by a curve the output of a large city for a year. This curve is plotted on percentage values of the daily 24 hour output during each month of the year. Plate III illustrates by similarly constructed curves the hourly variations in the output, during one day in winter and one day in summer. Plate IV shows the record chart of the governor delivery pressure in a typical district during one day in winter. Plate V shows the governor pressure on the same district during one day in summer.

In the distribution of gas, the means employed to regulate the flow from the storage holder to the street main usually include some form of controlling or governing apparatus, which is operated either manually, semi- or wholly-automatically, to preserve certain predetermined pressure conditions in the street mains. Originally in the early days of gas history the gas engineer could supply his district direct from a single lift, light weight holder. Later, however, increased consumption required greater storage capacity necessitating multiple lift holders giving pressures which varied with the

number of lifts cupped. The extended use of gas through

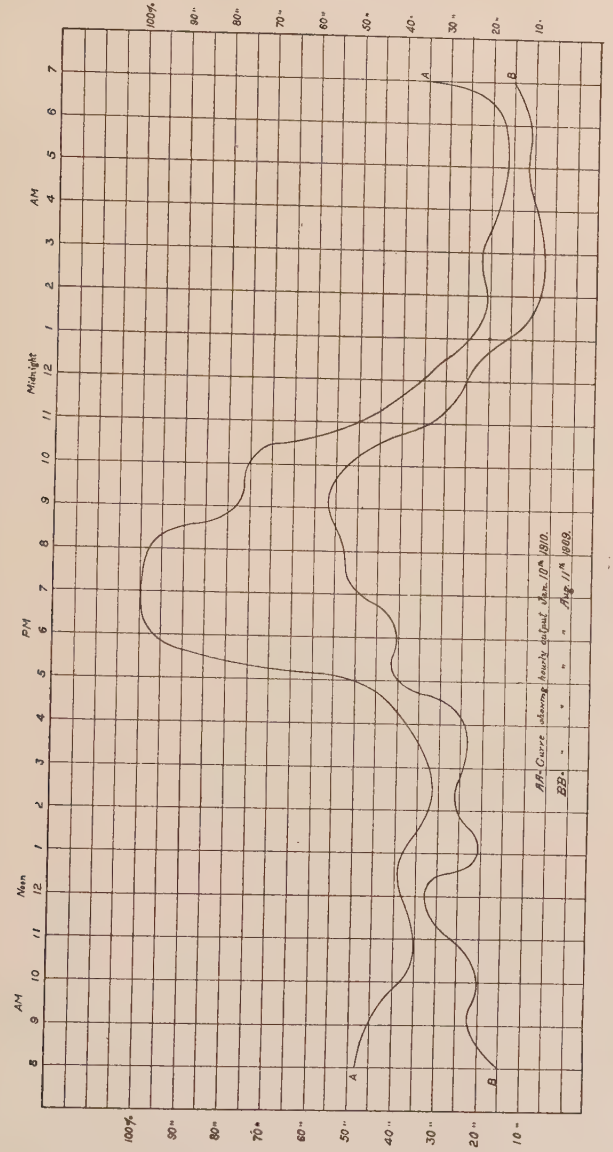
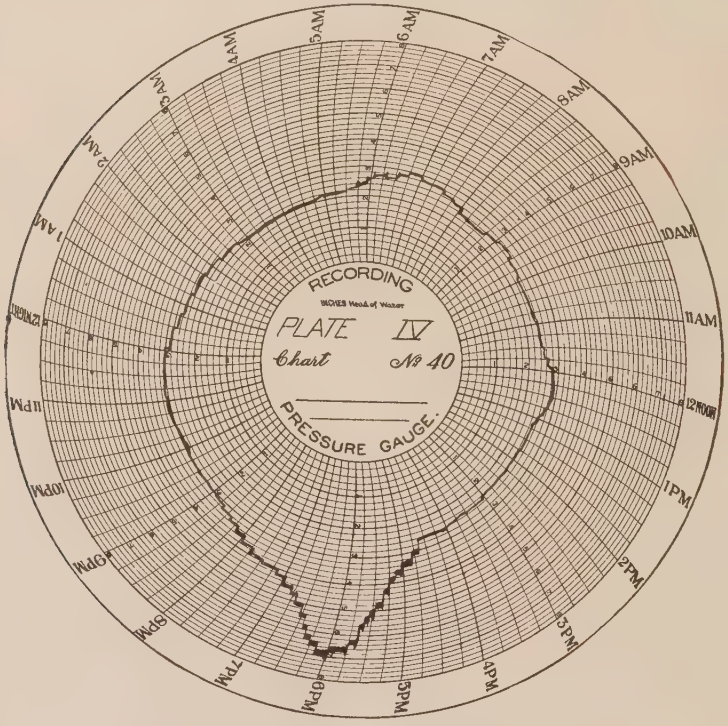


Plate III.

a variety of consuming devices and irregular consumption

produced conditions which required some form of governor inserted between the holder and the street main to properly supply gas to the district in quantities sufficient to meet the varying demands and at pressures suitable to the appliances consuming same.

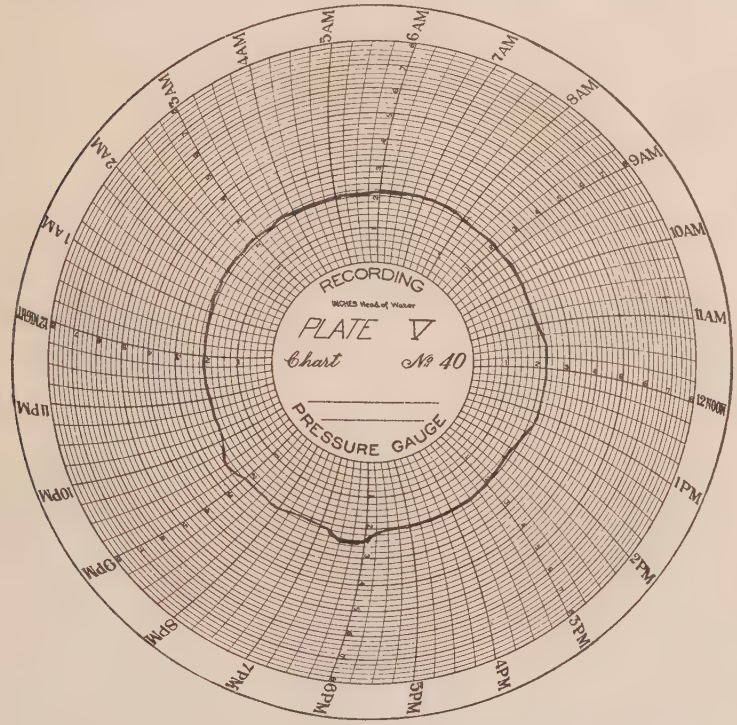
Station governors were gradually developed to meet these



Station chart showing pressure on a typical district during one day in winter.

requirements and are to-day universally known and used in two well defined forms, the so called "balanced" governor and the "automatic". The balanced governor is really semi-automatic in its operation and is the more universally used. It is a sensitive regulating valve carried by a float or inverted bell operating in a water seal, the float being influenced and

supported by the outlet pressure and suitably counterbalanced by adjustable weights, the resultant effect being that the area of port or valve opening is automatically varied, so as to maintain a constant predetermined outlet pressure. The outlet pressure is changed manually by a readjustment of the counter weights, this operation being necessary at different hours of



Station chart of pressure on the same district as Plate IV during one day in summer.

the day to meet the varying demands for gas for lighting or cooking purposes.

The automatic governor is self loading, the re-adjustment of the counterweighting being performed automatically, usually by a transfer of a liquid, either water or mercury, to or from a reservoir on top of the float or bell. This automatic

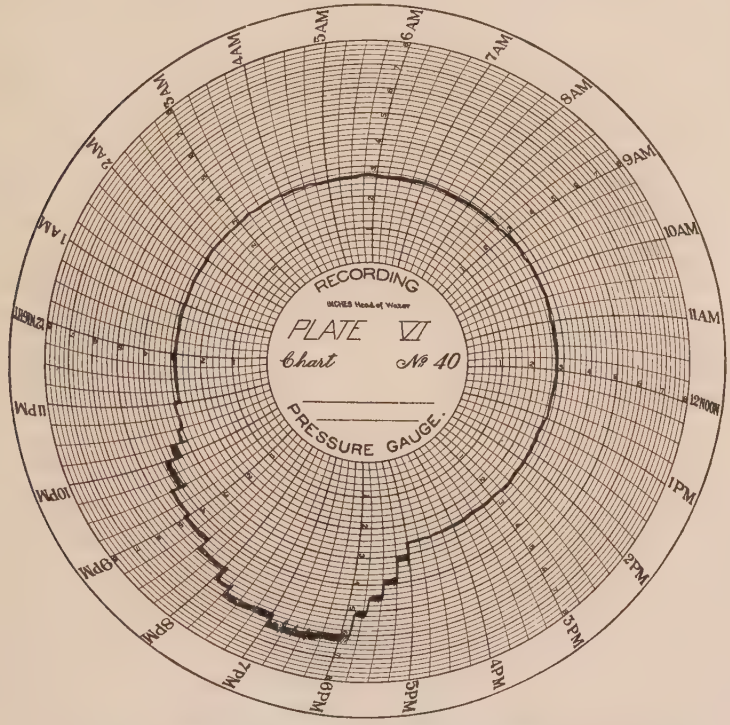
actuation is performed by the variation in the volume of gas flowing, or the draught from the mains, producing an increased initial pressure to the street main at the times when same is required and suitably decreasing same as the demand for gas becomes less.

The successful operation of an "automatic" governor is only possible, however, within certain limits of maximum and minimum outlet pressure and it cannot be operated to control districts which are supplied or "backed up" by gas coming from other sources. Furthermore the automatic governor is operated more particularly by the pressure conditions existing close to the governor or valve house and is not much influenced by the pressure in distant areas where proper regulation is really more important.

It was formerly the practice to arrange and adjust the governor or valve outlet pressures to meet the variable demand by a predetermined schedule, which was arranged in accordance with the hour of the day, the season of the year or experience obtained from a study of the charts of a number of recording gauges installed over an entire district. Experience has shown, however, that even the most careful prearrangement of the governor pressure does not produce reasonable uniformity throughout the district for well known reasons. A pressure schedule worked out from a study of the previous day's district pressure charts often proves on the following day to have been either inadequate or excessive. Sudden changes in weather conditions often upset such schedules leaving the entire situation in the hands of the valveman and his discretion does not always rise successfully to the occasion. Plates VI and VII show assumed characteristic charts of the governor and district pressures which are typical of these efforts to secure uniform pressure.

The inherent weakness of this system is the extent to which the personal responsibility or discretion of the governor attendant enters into the problem, and what might be termed the "time lag" or the inability to know results until after it is too late to correct them.

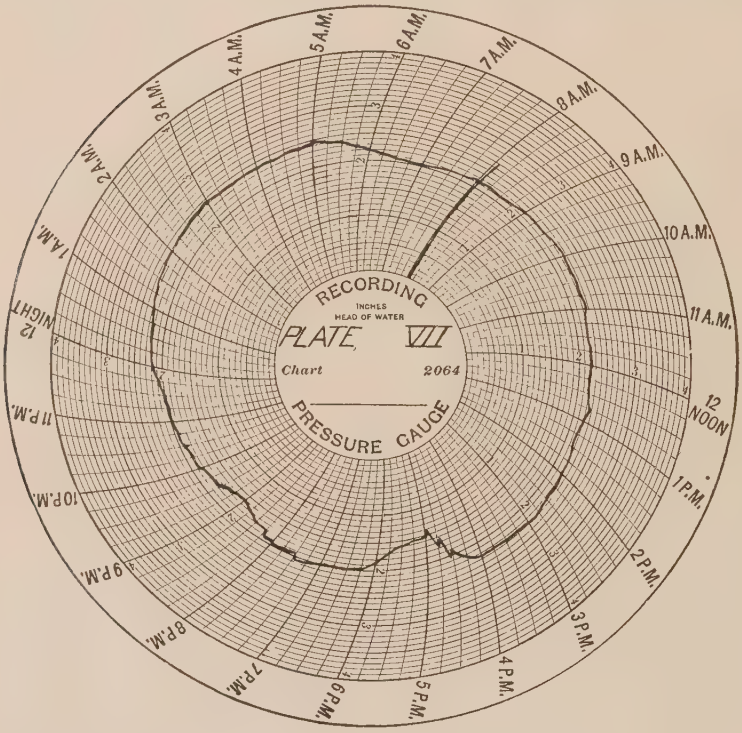
These conditions indicated the necessity for a system of instantaneous information and operation by means of pressure signals or indicating devices whereby pressures at points distant from the valve house would be instantly signalled or indicated by electrical means to the valve man, so that the governor or outlet pressures could be immediately adjusted to suit the requirements of the distant area in the district. The



Station pressure chart showing pressure adjusted according to a pre-arranged schedule.

importance of the service required an apparatus that was simple in operation, at least in its electrical functions, and that would automatically give visual indications that could not be varied or altered by line or battery trouble, temporary suspension of service, etc. In other words, the apparatus should be

operated without the use of variable resistances, changes of current strength, or reversals of polarity, and should give indications of definite pressure values, avoiding the necessity of checking or comparison by telephone or otherwise. A few such devices were known to be in use in this country but upon investigation were found lacking in some of the above



District pressure chart showing the result.

requirements. One instrument was imported from France but could not be operated successfully. An apparatus was designed especially for this service to meet the requirements outlined above, and which is hereafter described as the Telemetric Pressure Gauge, shown in Plates VIII, IX, X and XI.

These instruments are intended to be installed at various points in the district, the transmitters being located at points

which would give the best results for the surrounding district, and the indicators located in the valve houses supplying the districts. They are operated on electric circuits. Plates XII and XIII show typical results obtained from the use of these instruments. Plate XII is the station chart and Plate XIII is the record of the distant pressure. No matter what variations take place in the consumption out in the district, the station has instant information of the situation. In valve houses where a pressure man is constantly watching pressures, it is possible by the use of an electrical indicator to dispense with a governor, the regulation being performed by hand operated valves.

The apparatus is shown in Plates VIII, IX and X. Plate VIII shows the transmitter mounted in a cabinet, containing a tank with a float which is connected with the street main and is influenced by the pressure therein so as to rise and fall as the latter fluctuates. Plate IX shows a larger view of the transmitter movement. This instrument is located out on the district at the distant point which is generally two or three miles from the valve house. On top of float a vertical rack communicates its motion to a sensitive differential gear mechanism which is also part of a weight driven clock-work gearing held in check by an electromagnet. This magnet is in the electrical circuit which extends from the transmitter to the indicator (Plate X) in the valve house. When the pressure changes, the transmitter mechanism operates and transmits the proper signal to the indicator. The theory of operation is shown diagrammatically in Plate XI. The pointer of the indicator (Plate X) always points to a figure on the graduated dial which is the pressure at the distant transmitter. Whenever the pressure at the transmitter changes, the indicator pointer changes synchronously, operating with a perceptible click which attracts the attention of the valve man. If he adjusts or changes the governor or outlet pressure the indicator pointer will, after the lapse of fifteen or twenty seconds, the interval required by the gas wave to reach the distant

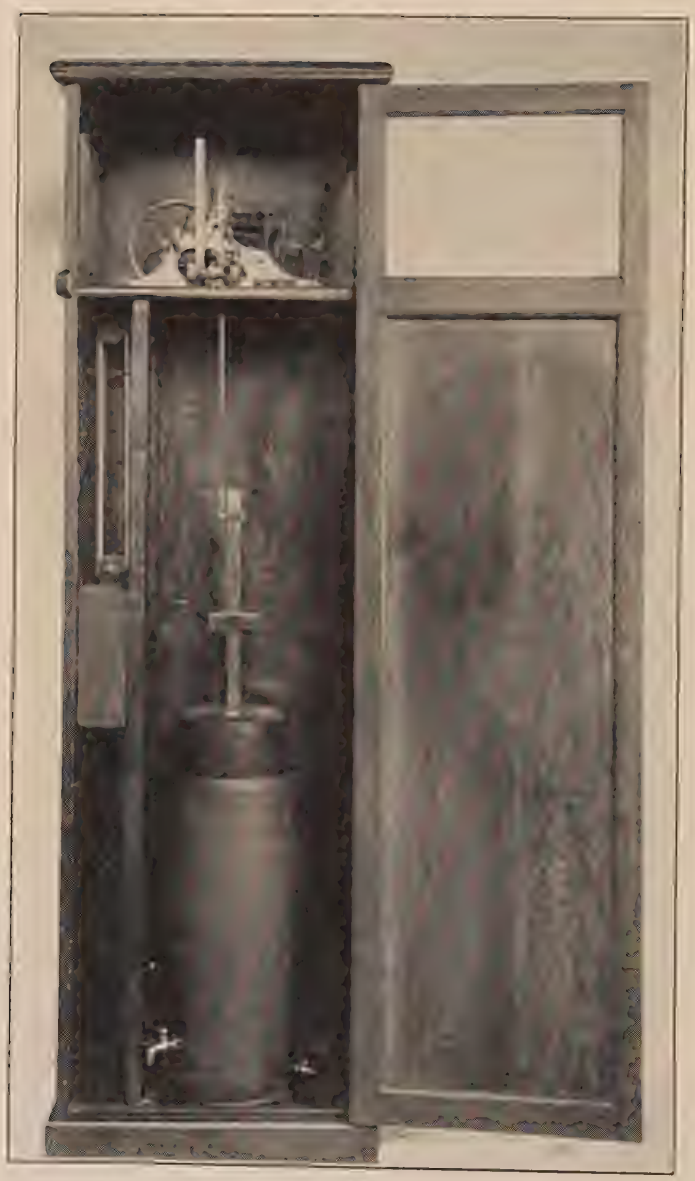


Plate VIII —Transmitter of U. T. P. Gauge with cabinet, tank, etc.

transmitter, respond to the change and shift its position to a new indication. The accuracy of the indicator can be tested

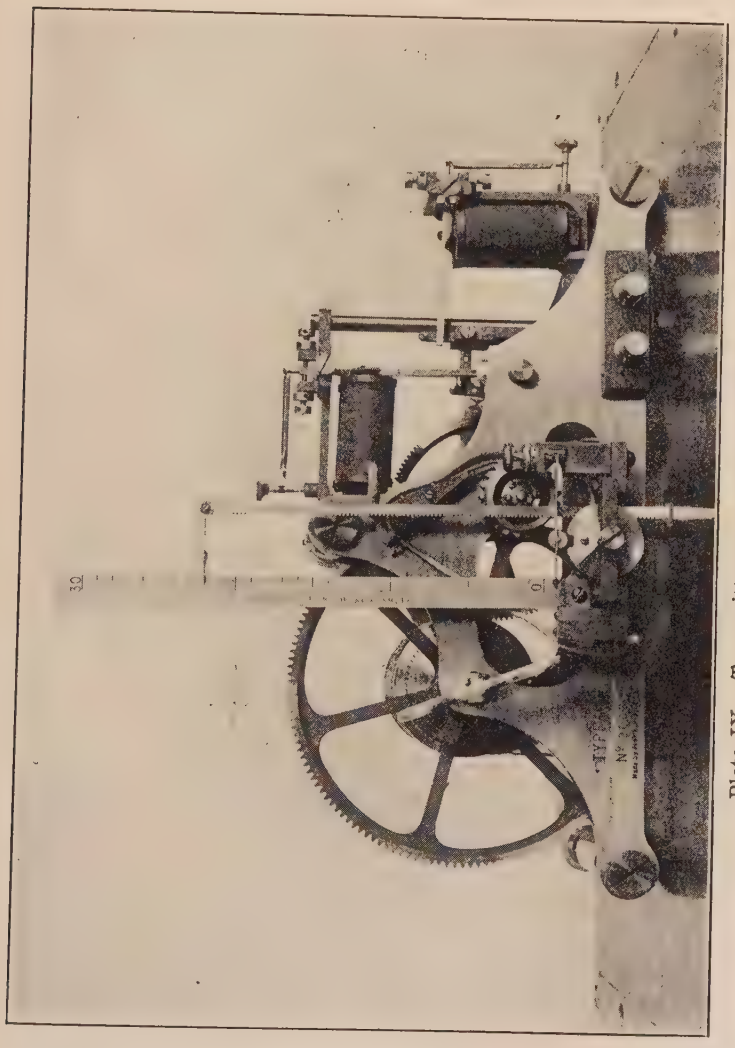


Plate IX.—Transmitter movement of U. T. P. Gauge.

and verified at any time by simply breaking the circuit by depressing a test key. This will cause the pointer to move

around the dial one revolution and resume its previous position, but in doing so it will pause quite perceptibly at the "zero" of the dial to exhibit or indicate its synchronism with the transmitter. The correct position of the pointer is thus easily verified or established. Line trouble is indicated by the

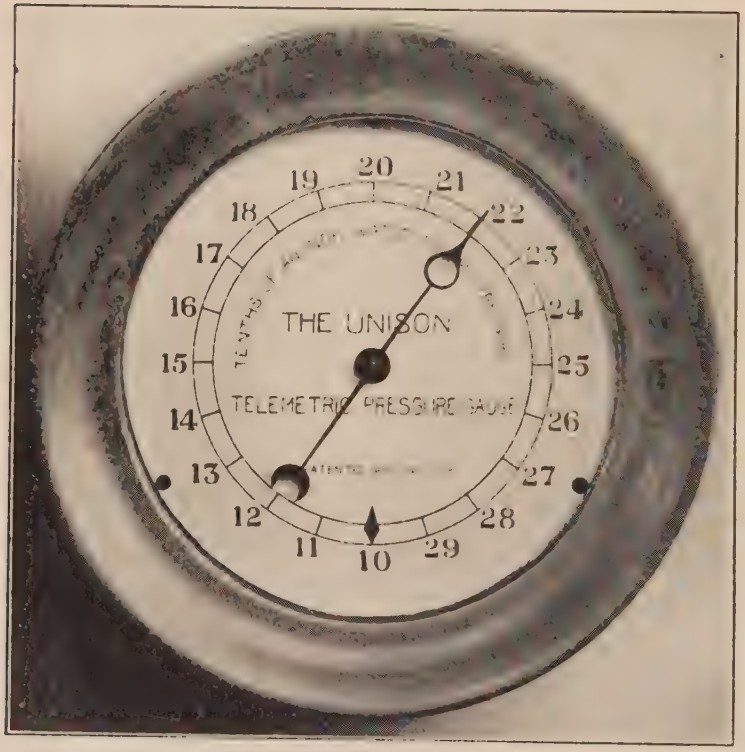
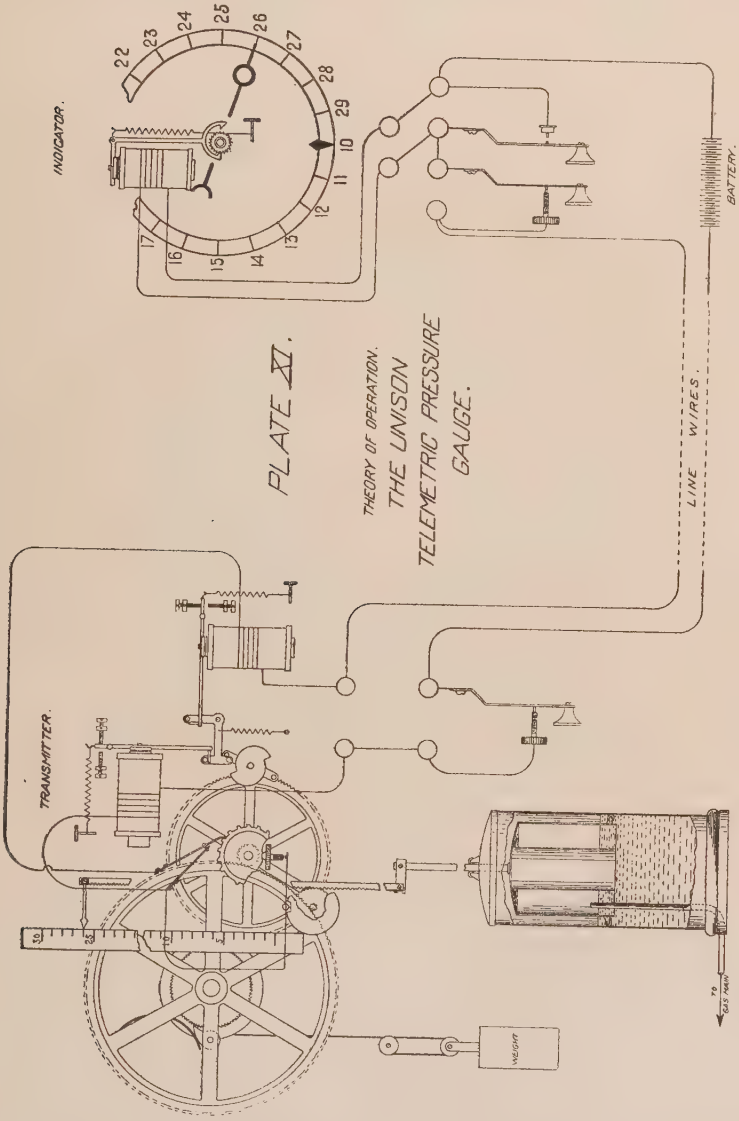


Plate X.—Indicator U. T. P. Gauge.

pointer assuming a position midway between the graduations and failing to respond to the test key. After the line has been restored to proper working order the indicator will instantly indicate the existing correct pressure, not the last pressure before the breakdown.

The transmitter requires to be wound at regular intervals. The form illustrated in Plates VIII and IX will drive the

indicator pointer around the dial about 500 times with one



winding. The instrument is also made self-winding, the

motive power being obtained from local batteries. Several indicators can be used on the same circuit and are non-interfering and operate in unison. In some cases where two valve houses deliver gas into the same district, one transmitter is used with an indicator in each valve house and by proper

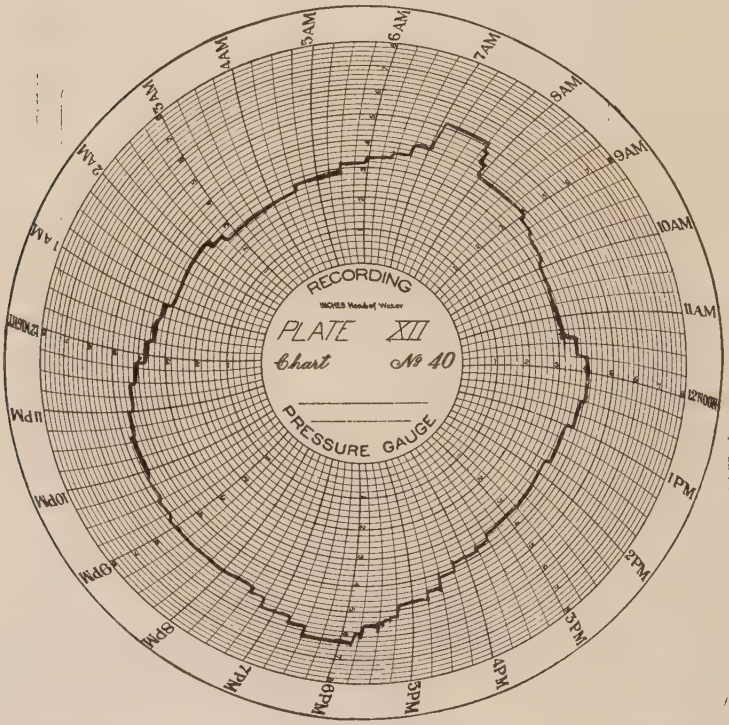


Chart of station pressure on a district equipped with U. T. P. Gauge.

instruction, the control of the pressure divided between the two valve houses.

The amount of current required by these instruments is about 0.070 ampere, which can be usually supplied by the local Telephone Company from their central energy transmitter batteries. In some cases the battery power is supplied by a

group of ordinary gravity or bluestone batteries, the number depending on the resistance of the line. These require renewals about once in three months. The up-keep of the instruments is small and with regular inspection they give

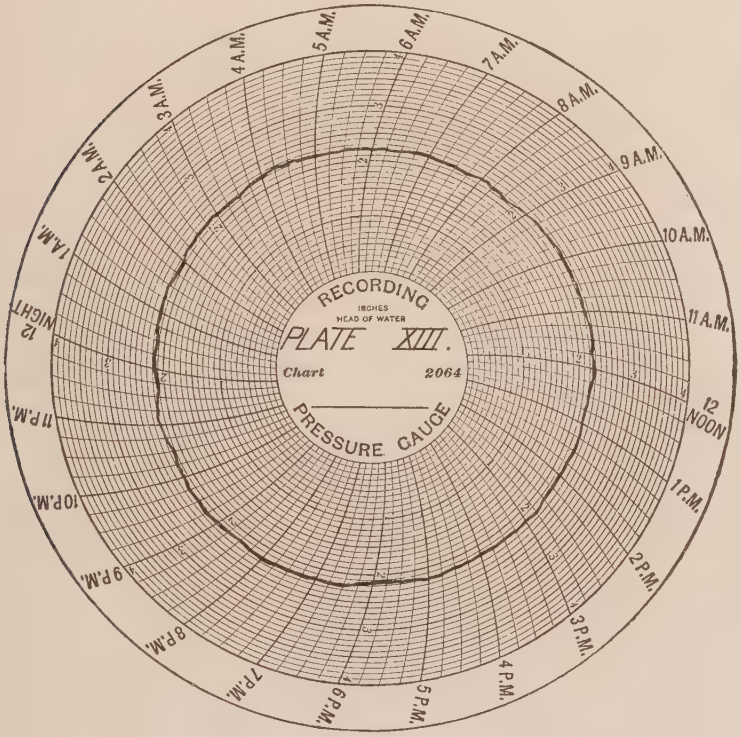


Chart of the distant district pressure showing the result.

excellent service. Only one circuit is required for each transmitter and a single wire with ground return may be used.

The electrical functions are extremely simple, the instruments being operated by impulses automatically impressed on the circuit by the transmitter simply "breaking and making" the circuit a certain number of times in succession with a regularity of intervals, except one, which throws the "pause" or verifica-

tion test when the pointer reaches the zero of the dial. No reversals of polarity or variable resistances are used, as these methods are known to be unreliable and subject to serious variations from line or battery trouble. If the water level in the transmitter is correctly maintained, the indications are error proof, which is a valuable feature in gas distribution when it is realized what a serious situation would be created by having an abnormally low pressure on the district but apparently correct on the indicator.

The instrument may be further applied to the actual operation of the governor without manual intervention, causing the indicator to automatically adjust the governor pressure to maintain a predetermined pressure at the distant transmitter. A diagram showing the operation of this apparatus is shown in Plate XIV. It has been in successful operation on one district for over a year. The transmitter remains the same, but a special controlling indicator is substituted which loads and unloads the governor so as to change or adjust its pressure in response to the distant pressure at the transmitter which it maintains constant. By shifting a plug at the indicator the distant pressure or setting can be changed. The indicator, besides operating the governor, indicates the distant pressure, and other indicators of the usual form (Plate X) can be inserted at other points in the circuit, as for instance in the Superintendent's office, thus giving complete supervision and verification of the operation of the apparatus. In case of line trouble the status of the governor is reduced to that of an ordinary balanced governor, maintaining the pressure at its last loading, and capable of being adjusted manually in the usual manner. This contingency can be indicated by an alarm bell or other means.

The special controlling indicator loads and unloads the governor by shifting the position of a weight on a floating lever connected with the governor arm, through the agency of a motor, which may be operated from an electric light circuit or by battery power. Plates XV and XVI are charts showing

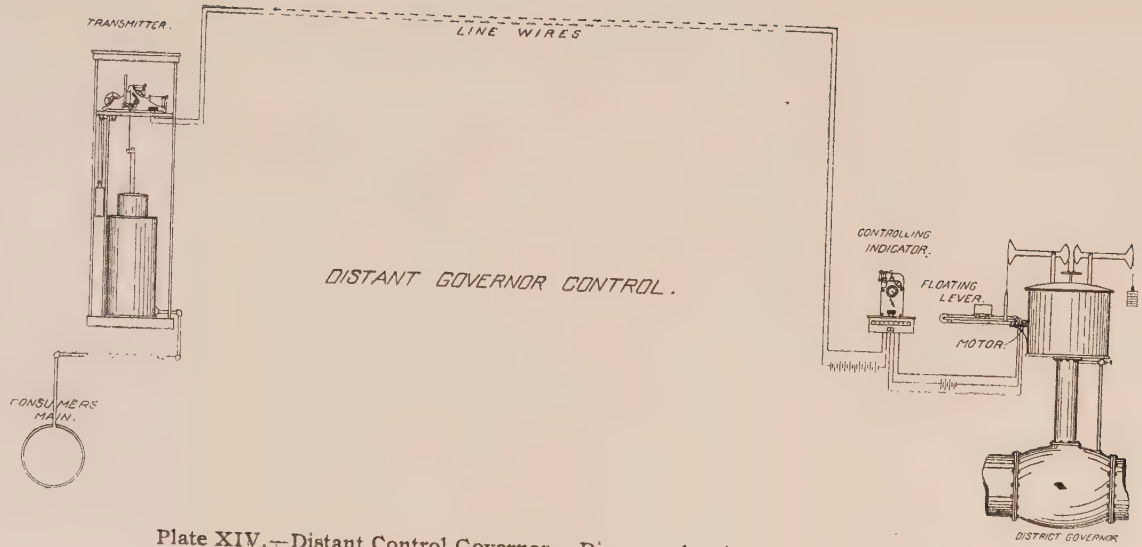


Plate XIV.—Distant Control Governor. Diagram showing method of operation.

the automatic operation of this apparatus, Plate XV being the governor pressure and Plate XVI the controlled distant pressure which is controlled within a range of one-tenth.

Plate XVII shows a photograph of an apparatus for signalling pressure audibly by means of an electrically operated

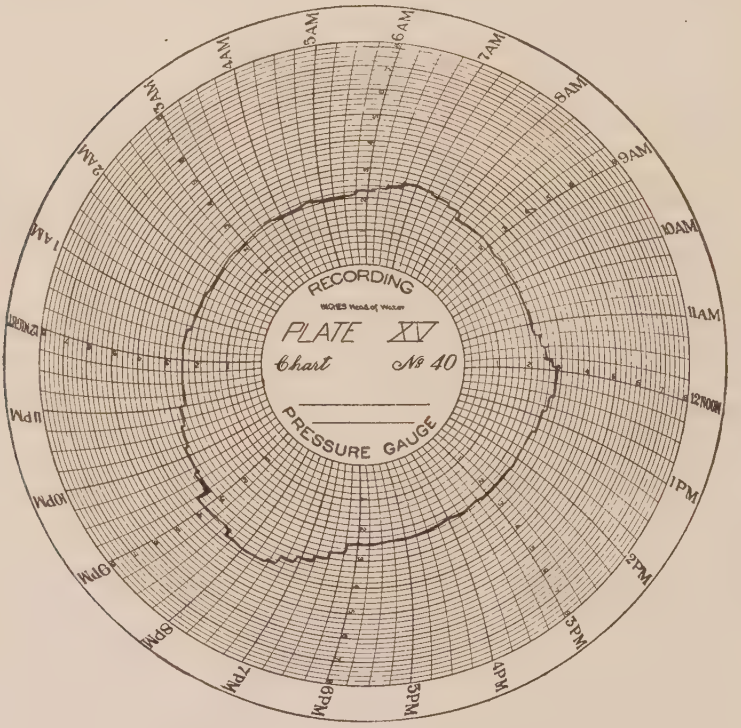


Chart of station pressure on district automatically operated and controlled by Distant Control Governor.

sound producing device, such as a single stroke bell, a telegraph sounder, etc. An instrument of this type has been in use in one installation for 30 years giving good results. Before the telemetric gauge was developed, other instruments of this type were installed and are still in use. While they are simple in operation and give positive pressure signals they

have the disadvantage of being non-visual and non-automatic. In order to ascertain the distant pressure, the attendant must interrogate the apparatus by depressing a key, listening and counting the strokes of a bell. If he forgets to frequently

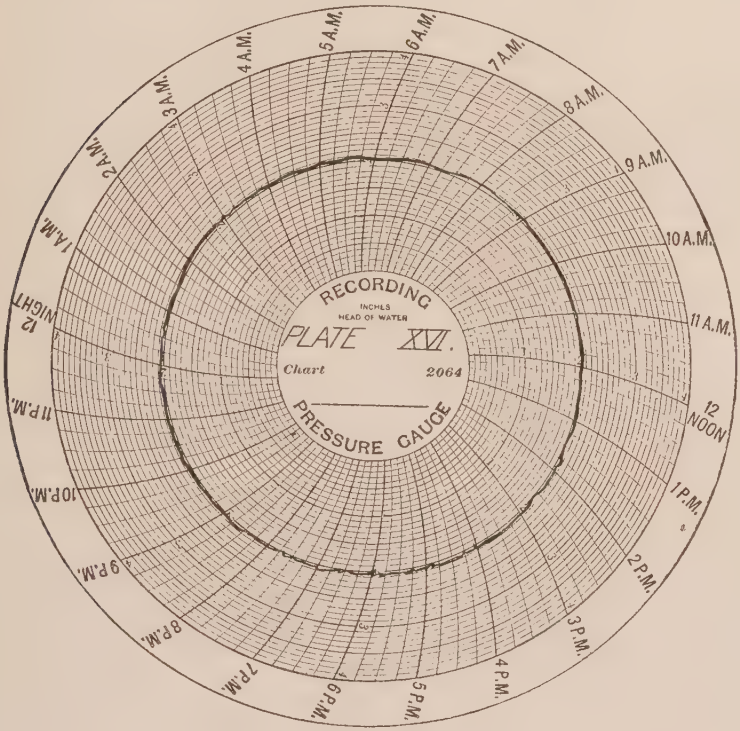


Chart of distant district pressure showing the result.

press the key, he is not informed of any change in the distant pressure.

The transmitter consists of a tank with float influenced by the street main pressure, and which carries a rack geared with a clockwork mechanism. Each change of pressure shifts the position of a contact finger with reference to a drum, the cylindrical surface of which contains a number of notches variously arranged and positioned. The gearing is weight

driven and is held in check by an electromagnet which is included in the main circuit. A circuit breaking key and a single stroke bell or sounder is located in the valve house at the distant end and also included in the circuit. When the circuit is opened and closed again by depressing the key, the electromagnet of the transmitter releases the mechanism and permits the drum to make one revolution. In doing so the contact finger falls into several notches on the periphery of the drum and breaks the circuit a certain number of times, depending on the position of the contact finger and which is controlled by the height of the float. The number of strokes on the bell or sounder in the valve house is thus made to indicate the distant pressure. The transmitter requires winding daily.

Another type of apparatus is shown in Plate XVIII (transmitter) and Plate XIX (indicator). One instrument of this type has been in use in one installation for several years. The indications are both visual and automatic and the indicator, besides indicating the pressure on a dial, makes a record of same on a time revolved chart.

The transmitter is connected by a cord to the pressure arm of a float gauge, which is influenced by the pressure in the street main. The cord passes over a drum, the pressure fluctuations causing the drum to rotate partially in either direction. When the pressure rises a unit, the mechanism closes the circuit for a moment and transmits an impulse in one direction to the distant indicator. When the pressure falls a unit, an impulse is transmitted in the reverse direction. The indicator is equipped with a special form of polarized relay, which when influenced by a positive impulse closes a local circuit which operates an electromagnet giving an upstroke to the indicating hand through a ratchet and pawl. When a negative impulse is received, the relay closes another local circuit operating a downstroke magnet, which drives the pointer down a unit by means of another ratchet and pawl.

This gauge with careful inspection and frequent comparison gives fair results. In gas distribution work, however, it is

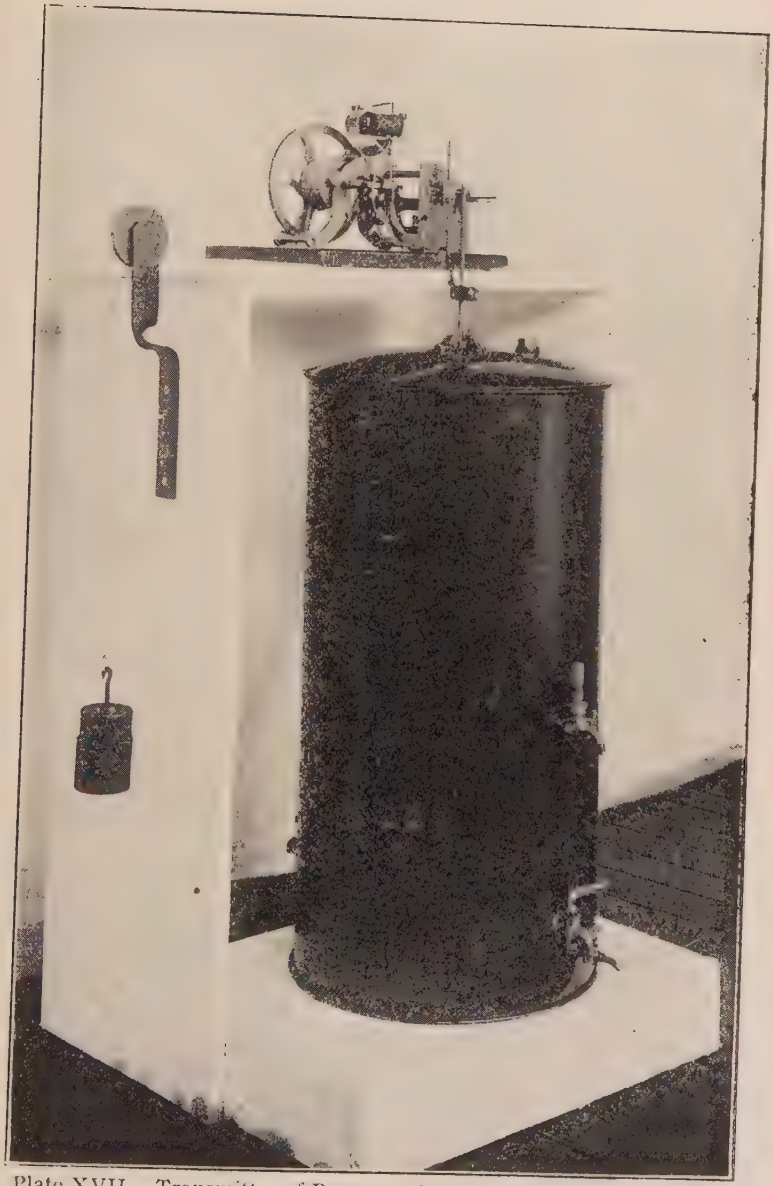


Plate XVII.—Transmitter of Pressure Signalling machine, indicating pressure at a distance by strokes on a bell or sounder.

Plate XVIII.—Transmitter of Dibble's Pressure Indicator. (Note:—The transmitter is mounted over the clock of a Pressure Recording Gauge and connected to the pen-carrying arm by a cord at the rear.)

open to the very serious objection of being operated on open circuit, which renders it capable of indicating pressure when

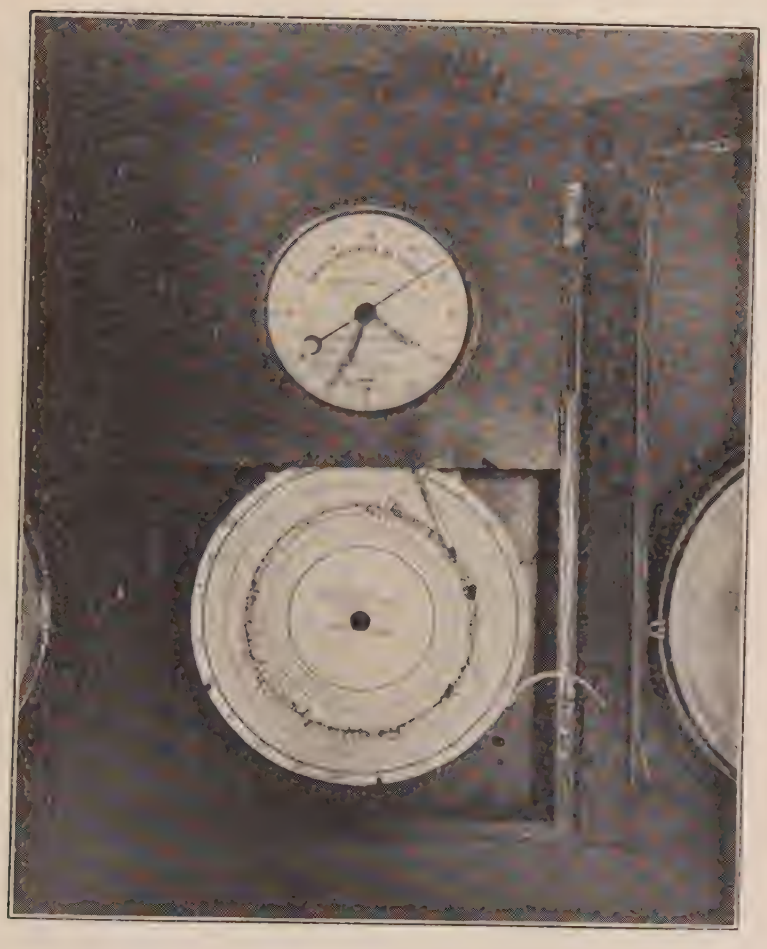


Plate XIX.—Indicator of Dibble's Pressure Indicator.

the line or battery may be at fault or out of commission. It requires frequent checking by comparison over telephone, which at night time, when its service is of greatest value, is objectionable.

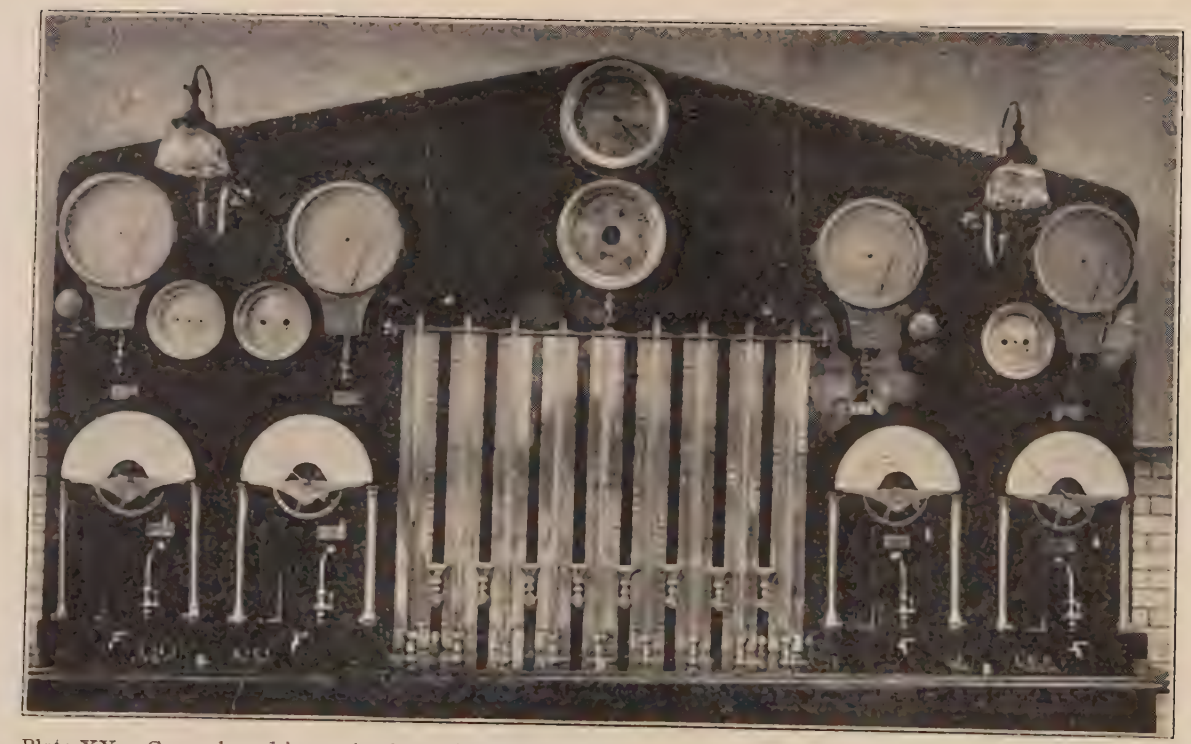


Plate XX.—Gauge board in a valve house in New York City. The arch gauges indicate the pressure on outlets of district governors, the Bristol gauges directly above record this pressure, and the Telemetric Indicators and bells indicate the distant pressure produced by same in each district

In conclusion it may be stated that the service necessary to give satisfactory results to heating and lighting consumers is one which requires instantaneous information and control of the distribution pressure in distant areas in order that a fair uniformity may be obtained. This is best obtained by electrical means either as outlined above or by some other method producing equivalent results.

Any apparatus, device, or method of operation which improves the service between a public utility corporation and its patrons, serves, a very useful purpose, whether it be for transportation, light, heat, physical energy or intelligence.

THE PRESIDENT: Mr. Kennedy has given us a very interesting paper. It may be found useful in many cases where pressure is regulated by ordinances.

MR. MCKAY: I am asked to read this discussion for Dr. Wing of the Boston Consolidated Company. (Reading.)

We have used a "Unison Telemetric" pressure gauge as a precaution against blowing the seals of purifiers, indicating in the exhauster house about a quarter of a mile away, and are well satisfied with the system.

The dial is graduated to indicate half inches, from 16" to 27", and the frequent changes of pressure are reliably indicated.

Unfortunately we located the transmitter in the purifying house and found it impossible to prevent the lime and oxide dust and the corrosive gases from destroying the electric connections.

This trouble is overcome if the apparatus is placed where it has a reasonable chance to stay in good order.

THE PRESIDENT: Is there any gentleman who would like to discuss Mr. Kennedy's paper? If not, I will ask Mr. Kennedy to close if he wishes to make any further remarks.

MR. KENNEDY: I think there is no need for further remarks.

A vote of thanks to Mr. Kennedy for his paper was then duly carried.

THE PRESIDENT: The next paper is

PUMPS FOR GAS WORKS PURPOSES.

BY MR. H. L. UNDERHILL.

MR. UNDERHILL: I ask that the paper be read by title.

THE PRESIDENT: In order to save time, Mr. Underhill will consider his paper as read. We thank Mr. Underhill just the same for his labor and the trouble in preparing the paper.

PUMPS FOR GAS WORKS PURPOSES.

The process of gas manufacture depends to a considerable extent on the continuous operation of numerous auxiliary apparatus among which pumps occupy a very important position, yet as a rule no part of the plants mechanical equipment receives less attention, in selection, attendance or repair.

The fact that pumps will continue to operate, although in a very inefficient condition, coupled with the difficulty of ascertaining their power consumption has led to their neglect.

In the following pages an attempt has been made to discuss gas works pumping apparatus in relation to its installation and maintenance, and also the suitableness of types and materials of construction for various gas works services.

INSTALLATION, CARE AND MAINTENANCE OF PUMPS.

If possible, all pumps should be put on a suitable foundation in a convenient as well as a clean place; however, if conditions demand their installation in a dusty location all external moving parts should be protected by canvas or preferably light metal removable covers. Special care should be taken to so place the pump as to provide accessibility and room for the removal of pistons, rods or other parts subject to wear. These precautions with the additional ones regarding air chambers as mentioned below, will reduce to a minimum wear due to vibration or grit and dirt. If possible pumps should

not be located in out of the way or unfrequented places. When exposed to view they generally receive better attention and their installation in groups in a pump room is especially desirable.

A steam pump should receive as much attention as a steam engine. All repairs and adjustment should be looked after by a competent mechanic, who should see that all pump parts especially subject to wear are kept in stock. Pumps should be thoroughly inspected at regular intervals. This period should be governed entirely by the class and amount of work required of the pump. Many unpleasant occurrences and accidents can be thus avoided, as well as preventing the excessive loss of efficiency due to wear. It is very important that all parts of the pump cylinders be made of proper metal to withstand chemical action of the liquids handled (see table No. 3).

Every effort should be made to maintain direct acting steam pumps up to their full stroke so as to obtain their full capacity and prevent loss of steam through excessive clearance. Simplex pumps seldom short stroke but Duplex are very liable to do so, thereby reducing their efficiency.

The installation of suction and discharge air chambers to prevent water hammer is desirable on all types of reciprocating pumps. They should be from two to four times the volume of the water cylinder in Simplex pumps and from one to three times the volume in Duplex pumps according to the speed and pressure. In both cases the air chamber should be high in proportion to their diameter, which in the case of the suction air chamber should be the same as the suction pipe. Suction air chambers should be so located that the energy of momentum of the column of water can be cushioned directly by the confined air (see Comparative Value of Different Arrangements of Suction air Chambers on Pumps—by F. Meriam Wheeler, Vol. 22, Trans. A. S. M. E., N. Y. C.). Both suction and discharge air chambers of important pumps should be provided with gauge glasses for ascertaining the amount of air in them.

Water should not occupy more than one quarter of the air chambers and in high speed pumps it is often found necessary to supply air to the discharge air chamber.

Suction and discharge piping should have as few bends as possible, and where bends are required they should be of the long turn design, especially in suction piping. Where long suction pipes are necessary, the size called for by the pump should not extend for more than 200 ft. from the pump, the additional pipe being of a size larger, and it in turn increasing one size every 200 ft.; the connections between the various sizes being made by long tapered reducers.

Foot valves, with strainers of design capable of being easily raised for cleaning while in operation, are desirable when pumping liquid containing refuse; the foot valve being especially desirable on long suction pipes. In some cases either single or twin readily accessible strainers placed in line near source of supply will be found desirable. Suction pipes should wherever possible be installed so as to drain towards the source of supply without pockets either for the collection of air or sediment. Suction and discharge valves should be either of the gate or angle globe types and all 3 in. or over, should be of the outside screw, flanged pattern.

Valves in the suction pipe should have the stems carefully packed and kept tight; air leaks in valve stem packing boxes are too often overlooked. The materials of construction of all parts of the suction and discharge piping, valves etc. should receive the same consideration as the pump.

Steam pipes leading to a pump should be so arranged that the water of condensation while the pump is idle, does not pass through the steam chest and cylinder and wash off the lubricating oil. Drip cocks should be attached to the steam pipes, and all large steam supply pipes should have separators with steam traps.

There are many types of regulators for controlling the pressure delivered by steam driven pumps, but as a rule some make of steam reducing valve (preferably without metallic

diaphragm) will be found most desirable owing to the fact that the troubles incidental to small pressure pipes from the usual pump governor to the discharge line are done away with, as none are required. Engine or turbine driven pumps should also be fitted with maximum and minimum speed control devices, and in common with all automatically controlled pumps on intermittent flow service should have automatic relief valves on their discharge lines.

Boiler feed pumps should be fitted with regulators designed to always maintain a pressure any desired amount greater than the boiler pressure, regardless of the variation of the latter. In selecting automatic regulators or governors care should be taken that they are of such a size that they will open sufficiently to prevent wire drawing.

The packing of pumps should receive care and consideration. The rods and plungers should be packed just tight enough to prevent more than moderate leakage, and the packing renewed often enough to keep it tight and pliable, in which state it readily absorbs oil. Old packing will upon examination be frequently found to be hard and full of sand and grit which naturally has a tendency to cut the rod. There are numerous styles and makes of metallic and non-metallic packing on the market. Efforts should be made to use metallic packing on all iron or steel steam rods above 1 in. diameter, provided the same part of the rod does not enter both steam and water cylinder packing boxes. Owing to the fact that almost all packing boxes on pumps are too small and shallow, special care must be taken in selecting packing of the proper quality and size. It should be put in with a view of securing the greatest possible degree of elasticity, so that the rod or plunger may be kept fairly tight with the least pressure on the packing. When cutting packing rings the length should be such that the ends do not come together when set up. A soft packing should be cut shorter than a hard packing. In both cases rings are cut shorter as the diameter increases. This is done to allow for the greater linear expan-

sion of the larger rings. Rings should be put in so as to break joints thus preventing leakage through them. When inserting packing the rings should be put in one at a time. using a piece of hardwood for pushing them to the bottom of the packing box and firmly against one another. The packing box should be filled as full as possible and the nuts on the studs started by hand; then start the pump slowly. If leakage occurs, do not attempt to tighten the nuts while the pump is in service, and in all cases tighten them only enough to stop all but slight leakage. A slight leak at the water rod or plunger is not usually harmful as it in a measure serves as a lubricant. Packing for the water piston should be cut and put in place as described above for packing boxes.

When the lining of a packed piston pump is in good condition, a cast iron, bronze or white metal, solid, water or labyrinth grooved ring makes a desirable piston packing; the ring should be as long as possible, preferably full length of piston. This style of packing wears well and does not cause as much friction as fibrous packing, it however, is not as tight as the latter when it is in good condition. Compressed fiber rings, if not allowed to dry out while pump is not in use, also make a serviceable piston packing for all services except cold fresh and salt water.

Rods and plungers should be close running fits in the bottom of their packing boxes, if this is not the case metal bushing rings should be put in in front of the packing to prevent same being drawn into the cylinder.

Pump valves and seats should be kept in good repair; reseating devices may be obtained for facing up the seats, while the valves if of cast metal or hard composition may be faced in a lathe. Soft rubber composition valves may be smoothed up by rubbing with ground emery on a file surfaced steel block.

Pumps should be equipped with adequate lubricating devices as the maintenance of their efficiency depends largely on proper lubrication.

Steam pumps which are operated at variable speeds should be equipped with mechanical, cylinder lubricating, sight feed force pumps, the oil is thereby fed at a rate in proportion to the speed. In all cases a sight feed, cylinder lubricating device of some kind should be used so that lubrication may be intelligently controlled. Plungers, rods and shafts working in and out of water ends of water pumps should be lubricated with a mixture of graphite and melted tallow, and all steam rods with cylinder oil, as the life of packing is thereby increased and wear and friction reduced. Oil supplied, felt wipers encircling the rods and plungers are frequently found desirable. Care must be taken, however, not to use too much tallow or oil as they may go beyond the packing box and contaminate the liquid. Pans should be used to catch excess oil or tallow which may be used again.

Powdered graphite either alone or mixed with oil may be used to advantage in both steam and water cylinders, but should be use sparingly.

Stoppage in or lack of capacity of suction pipe of valve chamber is generally indicated by jerky action and pounding of the water plunger or piston, while a dull thud at the end of the stroke is more often due to lack of air in the air chambers, or when speed is high, to lack of capacity of same. The regular inspection of strainer on suction line renders frequent examination of the interior of the pump unnecessary.

When a pump works properly under a certain condition of suction and discharge pressures and fails to work under different conditions, the difficulty is generally found in the lift of the valves or tension of the valve springs. When one side of a Duplex pump makes a quick stroke it indicates either that the packing box gland of the cylinder of the opposite side is too tight, or that the packing of the side, making the quick stroke, is wearing out or has perhaps given way. A defective discharge or suction pump valve will also cause a jerky motion of the piston and hammering in the discharge line.

If any difficulty is experienced in making a new pump work properly when first started, it will generally be due to leaks through imperfect connections, leaky pump valves or from temporary stiffness common to a new piece of apparatus.

For corrosive services it is often found advantageous to frequently paint the interior of the water ends of pumps with special anti-corrosive paints.

When pumps are installed in duplicate, the idle pump should be operated for a few minutes at least once a week, care being taken in the case of reciprocating pumps to leave them at a different point of the stroke than they were previously, the object being to prevent the pitting action of the packing becoming localized. When pumps are placed in storage all non-metallic packing should be removed and all machined exterior and interior parts thoroughly coated with anti-rusting compound.

Pumps that are exposed to low temperature in Winter should be fitted with drain cocks for emptying the cylinders and valve chambers of steam and water ends, and also to allow the water to flow out of suction and discharge pipes. If left out of service for any length of time both cylinder and steam valve chamber plates should be loosened.

DESCRIPTION OF VARIOUS TYPES OF PUMPS.

Hand Pumps.

Hand pumps are mainly used for pumping drips when mechanically driven pumps would not be feasible or labor saving. The ordinary light weight, lever handle house pump with free discharge is commonly used for portable work, while a lever handle yard pump is usually the type chosen for stationary work. For pumping street drips a closed top body or standard of free discharge or force pattern should be used to prevent splashing.

Crank operated reciprocating pumps require but two-thirds the labor to work, but are heavier, more complicated and cost more than the lever type. Hand operated rotary pumps

similar to power driven pumps of the same type are also suitable for pumping thin drip, lubricating oil, ammoniacal liquor etc. but are more subject to wear and more difficult to repair than the common lever pumps mentioned above. The deep well lower cylinder is desirable when the suction lift is over 20 ft. or even 10 ft. when the liquid to be pumped is hot or viscous and is essential for suction lifts over 24 ft.

Single acting lower cylinders are usually preferred on account of the light weight pump rods which may be used and because of their greater simplicity and compactness. Care should be taken to thoroughly secure all cylinder and pump rod joints, as vibration is liable to work them loose.

The usual type of upper body for operating lower cylinder is similar to the yard pump pattern noted above: Steam operated cylinders, however, can usually be used to advantage, saving time and labor.

There are many other forms of hand pumps, some of which are mentioned under Miscellaneous Types.

Steam Pumps.

Types of Water Cylinders.

The *packed piston pattern* of water end is the type used more than any other on account of its simplicity, low first cost and compactness. If properly designed and constructed for the work required, it will give good service when handling clean liquids at pressures up to 125 lbs. per square inch.

The weak point of this pattern is the packed piston, leakage by which is not discoverable until it becomes so serious as to cause a large increase in piston speed to maintain the usual delivery and to the fact that any gritty matter in the liquid handled is washed back and forth in the cylinder with the consequent scoring of the lining, causing increased leakage.

The *plunger pattern* is considered the most desirable for almost all conditions when a discharge pressure above 125 lbs. per square inch is desired owing to the fact that leakage by the plunger is readily discovered and rectified. It is also

especially suitable for handling gritty liquids; but it is not, however, capable of as high piston speed as the piston pump on account of greater weight of moving parts.

There are two common arrangements of plungers, viz; the centre packed and the outside end packed—the latter being practically two single acting pumps placed back to back.

The centre packed type has the advantage of occupying less space—there being no moving parts beyond the rear end of the water cylinder, the plunger is better supported and may also be easily removed for repairs.

Its disadvantages in comparison with the outside end packed type, lie in the fact that an additional packing box is required, (the one on the rod), and that for very high pressure, the unbalanced plunger (due to the rod) causes an unequal delivery.

The most desirable style of body and valve chambers for high pressure work for either of the above types of plunger pumps, is of the so-called pipe design, with separate pots or pockets for every valve, which are usually of the guide wing guard type without stems.

The valve pots should be secured to the suction and discharge headers by through bolts (instead of stud bolts, as usually provided), so as to facilitate replacing of joint gaskets, and when designed for very high pressure work, the various joints should be of the tongue and grove type. Gland bolts should be conveniently located, yet so placed as not to seriously interfere with the packing of the packing boxes.

If possible, the outside end packed type, should be so designed as to allow the removal of both plungers without removing pump from foundation.

The *plunger and ring pattern* is not a very useful type as its range of service is limited to the handling of clean, cool liquid under low pressure and for fire purposes (see National Fire Protection Association Specifications).

The tightness of the plungers depends on the fit of the metal ring, any wearing or scoring of either causing leakage.

A modified design of this pattern, consisting of a plunger with a gland packed ring should be a useful pattern for low pressure work, especially for handling gritty liquids, however, it does not seem to be used to any great extent.

Steam Crank and Flywheel.

The patterns of water ends noted above, are used on flywheel pumps as well as on direct acting type, and are applicable to the same services.

Power-Reciprocating.

The *reciprocating* type is sometimes built with ordinary packed piston, double acting cylinders, but is usually arranged with single acting plungers which are operated by connecting rods, driven by cranks or eccentrics.

The valves are usually of the guide wing guard type, similar to the ones mentioned under plunger pattern of direct acting steam pumps.

The Multi-cylinder (usually three) single acting, plunger pattern is the most desirable type on account of the even distribution of energy required with consequent regular discharge, greater simplicity and lower first cost.

Power-Centrifugal, Volute and Turbine.

Centrifugal pumps are built in volute and turbine patterns, in single and multi-stage and for wide ranges of capacities and discharge pressures. To obtain satisfactory results each individual pump should be carefully selected for its specific working conditions, as the efficient range of a centrifugal pump is very narrow. They are not self-charging and to obtain the best results should be arranged to work under suction head, or at the most with a suction lift of but a few feet, in the latter case the pump body should be equipped with an ejector for charging process. They are incapable of handling vapor or air to any extent without losing suction; in some cases vacuum pumps connected to air chambers in the suction line are installed to overcome this difficulty.

Pumps for handling large volumes should be arranged with double suctions to eleminate end thrust of the shaft. There are but few makes of multi-stage centrifugals arranged with double suctions; due consideration, however, should always be given to the means of handling end thrust.

Pump cases split horizontally on centre line of shaft are of advantage on account of ease of examination or removal of impellers, etc. Stuffing boxes and bearings should be separate and distinct from each other and impellers should be provided with renewable wearings rings where they are nearly in contact with case. Open and enclosed types of impellers are used and in general the open type is preferable for handling liquids containing grit, while the enclosed type is the most efficient and is capable of good results against high heads, but is subjected to more wear than the open type when handling gritty liquids.

Power-Rotary.

There are many designs of rotary pumps, but none of them are used to any great extent in gas works, although there are a number of services on which they might be used to advantage when working under conditions of moderate suction and discharge heads.

The most prominent difference between the two principal types of rotary pumps lies in whether one shaft with self-adjusting impellers or two shafts with fixed impellers are used.

Rotary pumps are self-charging for moderate lifts and are able to handle a small amount of vapor or air with the liquid without marked detrimental effects.

There are several other types of power pumps which in special cases might be desirable such as the Propeller pump for handling large volumes under conditions of no suctions and low discharge head and in a modified form for deep well service. The Screw pump might be also a useful type for handling clean liquids with a continuous and non-pulsating

discharge at pressures beyond the efficient range of a rotary pump.

Ejector and Injector.

The advantages of the ejector are its lightness, simplicity and low first cost. For small drainage purposes or small construction or temporary low pressure pumping operations and for the handling of acids, where the mixture of the operating medium with the liquid to be handled is not detrimental, it is a useful device, although far from economical. Ejectors should be submerged and their suction pipes provided with a check valve to obtain the best results. If operated by steam, the submerged portion of the steam pipe should have a water tight casing to prevent condensation. Grit in the liquid handled or in the operating medium will soon score the nozzles and thereby decrease capacity and efficiency. The nozzles should be replaceable. The ejector may be operated by either air, water or steam.

The *injector* is similar to the ejector, differing from it in that it is designed only for the use of live or exhaust steam or a mixture of both, and in being capable of forcing liquid against a pressure higher than the boiler pressure. Its sphere of usefulness is practically limited to boiler feeding, in which service it is very economical as nearly all of the heat as well as the water-base of the steam used is returned to the boiler. However, it cannot compete with the feed pump (unless simplicity, compactness and light weight are imperative) when the steam required to furnish power for the pump is used for heating the feed water.

The double nozzle type of injector is the most desirable design on account of its greater range of operation.

The exhaust steam (75 lbs. max. water delivery pressure) and the combined exhaust and live steam (150 lbs. max. water delivery pressure) injectors are, when the exhaust steam would otherwise go to waste, of necessity, more economical than the live steam injector.

Neither the injector nor the ejector will give satisfactory

service when the liquid to be handled is much over 100 degrees Fahr.

Among the numerous styles of miscellaneous pumping apparatus the air lift, pulsometer and diaphragm pumps occasionally find a place in gas works. The use of the air lift is mainly limited to the pumping of deep wells where it is possible to have at least 55 per cent. immersion of the air releasing device to 45 per cent. lift of water. The pulsometer and diaphragm pumps are for drainage purpose, the former operating by the direct introduction of steam while the latter is usually operated by hand although power driven outfits are also used.

General Remarks.

The ordinary, direct acting, simple, reciprocating steam pump is very largely used owing to its simplicity, ease of regulation, suction power, general utility and moderate first cost, also on account of its ability to operate under disadvantageous conditions of installation and attendance.

The Simplex type is as a rule more desirable than the Duplex owing to its greater simplicity and economy. However, it demands a somewhat higher degree of maintenance especially if it is to be run at low speed or by governor control, and if operated at high piston speed it is liable to cause water hammer in the discharge line. The greater economy of the Simplex over the Duplex is due to less working clearance in its steam cylinder on account of its greater ability to maintain full stroke.

Long stroke reciprocating pumps are preferable to short stroke on account of the fewer reversals with corresponding less valve movement for the same piston speed, and in direct acting steam pumps also on account of the smaller ratio of steam cylinder clearance to total volume of same.

Either of the above types of simple pumps uses from 100 lbs. to 300 lbs. of steam per I. H. P. according to its conditions and service, and the mechanical efficiency varies from about 50 per cent. to 90 per cent.

If pumps are kept in good condition the mechanical efficiency, *i. e.* the ratio of the water horse power to the I. H. P. of the steam cylinder will be well up to the higher figure, but usually averages only about 65 per cent.

Compounding of the steam will lower the steam consumption about 25 per cent. but is not usually desirable, when the high pressure cylinder would be smaller than 8 in. diameter or the steam pressure less than 100 lbs. per square inch, on account of the small possible monetary saving and the disadvantage of the multiplicity of parts.

The steam driven crank and flywheel and power driven reciprocating pumps are the most efficient types for many services, but in the majority of cases there bulk and weight, number of moving parts, high first cost and cost of attendance and maintenance more than offsets their advantages.

The centrifugal pump although not equal in mechanical efficiency to the crank and flywheel and reciprocating power pumps, is very desirable for duties within its range if suitable power is available on account of its moderate cost, simplicity, compactness, non-pulsating discharge, ability to handle dirty water and to be directly connected to electric motors and steam turbines.

The development of the medium speed, small steam turbine has greatly widened the field for centrifugal pumps; they are now designed for direct connection to each other and are reliable and efficient units.

The rotary pump except for somewhat high cost and greater bulk and its inability to handle dirty water or to be run at high speed has for low pressure work the same advantages as the centrifugal with the additional advantages of allowing direct connection to moderate speed reciprocating engines, greater range of control of rate of flow and discharge pressure and ability to lift water to some extent.

In general, when thin liquids are to be handled in a non-vaporous condition with little or no suction lift, some form of centrifugal pump is the most desirable, if economical drive

is obtainable; but when liquids must be handled under conditions of high suction lift or in a vaporous or thick condition, some form of steam or power driven reciprocating pump will be found preferable.

Structural Details.

The steam cylinders of constant service pumps of all but the smaller sizes should be lagged with non-conductive material to reduce condensation losses and they should not be larger than necessary to easily maintain the desired discharge pressure and speed when working under conditions of normal steam pressure, on account of the steam condensation being proportional to the square of their diameters. The steam cylinder should be so proportioned as to be able to produce from 25 per cent. to 33½ per cent. more power than theoretically required, so as to overcome friction and maintain desired speed.

The normal working capacity of reciprocating pumps with stroke 12 in. or over should be figured on a basis of not more than 75 ft. per minute piston speed when handling thin, cool liquids, while when handling hot or viscous liquids, not more than half that speed should be used. Pumps with less than 12 in. stroke should be figured at even lower speeds than the above, the maximum number of strokes being limited to 200 per minute.

The normal slippage of a reciprocating piston pump when in good condition is about 8 per cent. of the theoretical volume pumped, but in figuring average working capacity about double that amount should be used.

When handling very hot liquids, it is especially desirable that they should flow to the pump, for when hot liquids have to be raised, the reduced pressure on them lowers their boiling point, and the pump is liable to become vapor bound from evaporation at this reduced pressure. Thick viscous liquids should also flow to the pump and in common with hot liquids, their velocity should be kept much lower than that allowable

for cold water, which however, should not as a rule exceed 300 ft. per minute through valves and ports, when figured on a basis of 100 ft. per minute piston speed.

Reciprocating steam pumps for handling liquids other than fresh non-alkaline water should be so proportioned that the same part of the piston rod does not enter both steam and water packing boxes. In all but the smallest pumps it is also preferable to have the rod in two sections clamped together in the middle, thereby facilitating repairs and allowing the use of the rods of different material for steam and pump cylinders.

Packing boxes of almost all types and makes of pumps are of inadequate dimensions. On small pumps they should be large enough to take at least 3/8 in. diameter packing and on large pumps packing in proportion, preferably in sizes increasing by ⅛ in. to a maximum diameter of 1 in. The depth of the packing box should be sufficient for at least 5 or 6 rings of packing.

Packed pistons should be designed to take packing of the same diameter and number of rings as the water rod packing box.

There are a number of general types of pump valves which may be used with fair results on all gas works services, but it will be found much more satisfactory if a special type as well as a special material be selected for each service.

The commonest type of valve is the flat rubber composition disc secured in a stemless, guide wing guard or as a majority of cases guided by a central valve stem with a coil spring on top of disc. In most cases and especially for pressure over 50 lbs. discs should be placed in metal guards which encase the top and inner and outer edges of the disc, thus protecting it from defacement by the spring, wear by the stem and spreading. These valves are suitable, if proper degree of hardness is obtained for cold or hot fresh or salt water, but are not to be recommended for any of the other ordinary gas works services.

A disc valve made of compressed fiber is suitable for all gas works services except cold fresh and salt water, but if allowed to become dry is liable to curl out of shape thus preventing the catching of suction when pump is started up. However, for services not detrimental to the material a thin plate of Kinghorn bronze loosely placed against the seating face of the fiber disc will overcome the trouble caused by curling of same and also protect it from wear. The use of such a metal plate is especially satisfactory on the stemless, guide wing guard type of valves as it may in their case be securely fastened in place by the disc nut.

A special design of flat valve is also made from Kinghorn metal, it consists of three concentric thin plates guided by a central metal stem, and usually arranged with a lift stop instead of a spring. The lower plate is the full diameter of the valve seat, the second about seven-eighths of the diameter and the upper about three-fourths; the lower and middle plates are each perforated with four small non-matching holes to reduce the cushioning between them. When used on liquids not detrimental to this special bronze, this valve will as a rule give satisfactory results. Its chief defect consists of excessive wear at the valve stem. In general, however, if a flat disc type of valve is suitable, one of light cast metal of the proper composition will be found the most satisfactory both as regards service and cost of maintenance.

For handling coal gas tar or similar thick and viscous or muddy liquids, ball or sphere valves will be found especially satisfactory; although bell and hinged valves, the later with seats frequently placed at an angle to minimize catching of solid matter, are also largely used with good results. The first two designs do not have springs while the latter may be fitted with coil or flat springs or without any according to the condition of service. In all cases the valves and springs should be entirely of steel, cast steel or cast iron. Tar pumps should have ample handholes for cleaning and repair purposes.

Reciprocating pumps for handling salt water should have

"Marine" or similar type of water cylinders, with replaceable suction and discharge valve plates or decks, which may be either all bronze or cast iron with bronze seats. U. S. Navy Bronze (88 per cent. copper, 10 per cent. tin, 2 per cent. zinc) has good acid resisting qualities and is considered a very desirable composition. The corrosive action of polluted salt water is especially severe and cast iron pump bodies should be of extra thickness for this service.

Renewable linings for packed piston pumps are desirable on account of the tendency of the cylinders to score, cast metal linings being preferable to drawn metal ones. On salt water and other corrosive services, the linings of piston pumps should extend the full length of the cylinder, with port openings cut out of the linings; the front cylinder head should also be covered on the inside with a metal "sweat piece" so called to protect same from corrosion.

In the appended tables, pumping apparatus has been classified according to service, type of motive force and materials of construction.

Table No. 1 refers to the types of pumps suitable for the majority of gas works services, viz; boiler feed, condenser water, oils, tars, ammoniacal liquor, separator or circulating water, drips, hydraulic, fire and drainage.

In Table No. 2, the various types of pumps referred to in Table No. 1 are classified according to the general character of the motive force employed, viz; hand, steam, power and miscellaneous, and in Table No. 3, the materials of construction of various types of water ends of pumps are noted for the gas works services mentioned above.

TABLE NO. 1.

CLASSIFICATION OF PUMPS ACCORDING TO SERVICE.

Service	Types	Sub-division of types
Boiler feed.	Steam pumps.	Direct acting reciprocating. (Piston or plunger.)
	Power pumps.	Reciprocating. Single or double acting. (Single or multi-cylinders.)
	Power pumps.	Centrifugal. Turbine.
	Miscellaneous.	Injector. Live steam or combined live and exhaust steam.

TABLE NO. 1.—(Continued.)

Service	Types	Sub-division of types
Condenser water.	Steam pumps.	Direct acting or crank and flywheel reciprocating. (Piston, plunger, or plunger and ring.)
	Power pumps.	Reciprocating. Single or double acting. (Single or multi-cylinders.)
	Power pumps.	Centrifugal. Volute or turbine.
	Power pumps.	Rotary.
Oils.	Steam pumps.	Direct acting reciprocating. (Piston, plunger, or plunger and ring.)
	Power pumps.	Reciprocating. Single or double acting. (Single or multi-cylinders.)
	Power pumps.	Rotary.
Tars.	Steam pumps.	Direct acting or crank and flywheel reciprocating. (Piston or plunger.)
	Power pumps.	Reciprocating. Single or double acting. (Single or multiple cylinders.)
	Power pumps.	Rotary.
Ammoniacal liquor.	The same as "Tars," also	
	Power pumps.	Centrifugal. Volute or turbine.
Separator or circulating water.	The same as "Ammoniacal liquor."	
Holder, works and street drip.	Hand pumps.	Low lift or deep well. (Free or forced discharge.)
	Steam and power deep well.	(Single or double acting.)
	Steam pumps.	Direct acting reciprocating. (Piston or plunger.)
	Power pumps.	Reciprocating. Single or double acting. (Single or multi-cylinders.)
	Power pumps.	Rotary.
	Miscellaneous.	Ejector. Air, water, or steam.
Hydraulic.	The same as "Tars," also	
	Power pumps.	Centrifugal. Turbine.
Fire.	Steam pumps.	Direct acting reciprocating. (Duplex.) (Plunger and ring.)
Drainage	The same as "Separator or circulating water," also	
	Miscellaneous.	Diaphragm. Hand or power.
	Miscellaneous.	Ejector. Air, water or steam.
	Miscellaneous.	Pulsometer. Steam.

TABLE NO. 2.

CLASSIFICATION OF PUMPS ACCORDING TO TYPE OF MOTIVE POWER.

Hand.	Reciprocating.	Suction or low lift. (Free or forced discharge.)
	Reciprocating.	High lift. (Free or forced discharge).
	Rotary.	Low lift. (Free or forced discharge.)
Steam.	Direct acting reciprocating.	Simplex or duplex. (Piston, plunger or plunger and ring.)
	Crank and flywheel.	Single or double acting. (Piston, plunger, or plunger and ring.)
Power.	Reciprocating.	Single or double acting. (Single or multi-cylinder. Piston or plunger.)
	Centrifugal.	Volute or turbine.
	Rotary.	
	Propeller.	
	Screw.	
Miscellaneous.	Ejector.	Air, water or steam.
	Injector.	Live steam or combined live or exhaust steam.
	Air lift.	
	Pulsometer.	
	Diaphragm.	

TABLE NO. 3A.

MATERIALS OF CONSTRUCTION OF PUMPS SUITABLE FOR VARIOUS SERVICES.

HAND PUMPS.

Service.	Drips (Low Lift).	Drips (Deep Well).
Pattern.	Ordinary House.	Lower Cylinder.
Body.	C. I.	C. I.
Lining.	None.	None.
Piston.	C. I.	Bronze.
Piston Packing.	Canvas	Bronze Split Ring.
Rod.	Steel	Steel and W. I. Pipe.
Packing Gland.	None.	Bronze if any.
Valves;	Bronze.	Bronze.
Seats.	C. I.	Bronze.
Stems.	None.	None.
Springs.	None.	None.
Guards.	C. I.	Bronze.

NOTE.—Force pumps same as above except upper rods and packing glands should be respectively of steel and bronze.

Bronze should be U. S. Navy composition (88% Copper, 10% Tin, 2% Zinc.) C. I. = cast iron, W. I. = wrought iron.

TABLE 3B.

Materials of Construction of Water Ends.

Reciprocating Steam Pumps—Packed Piston Pattern.

Service	Body	Lining and Piston	Pump end rod	Packing glands and rod bushings	Valves	Valve seats	Valve stems	Valve springs	Valve guards
Boiler Feed....	C. I.	Cast bronze.	Tobin bronze.	Bronze or bronze bushed.	Bronze.	Bronze.	Bronze.	Phosphor bronze.	None.
Condenser water (F. & S.)....	"	"	"	"	Rubber Comp.	"	"	"	Brass.
Oils.....	"	"	Hammered steel.	"	Bronze.	"	"	"	None.
Coal gas tar....	"	C. I.	"	C. I.	Steel balls.	C. I.	None.	None	None.
Water gas tar...	"	"	"	"	Bronze.	Bronze.	Bronze.	Phosphor bronze.	None.
Ammoniacal liquor.....	"	"	"	"	C. I.	C. I.	Steel.	Steel.	None.
Separator or circulating water (W. G.)..	"	"	"	"	Bronze.	Bronze.	Bronze.	Phosphor bronze.	None.
Drips	"	"	"	Bronze.	C. I. or bronze.	"	"	"	None.
Hydraulic.....	"	Bronze.	Tobin bronze.	Bronze.	Bronze.	"	"	"	None.
Drainage.....	Materials should be selected according to the nature of the liquid handled.								

NOTE :—Hammered steel steam rods should be used when practicable. Bronze should be U. S. Navy composition, (88 per cent. copper, 10 per cent. tin, 2 per cent. zinc). C. I. = cast iron, F. & S. = fresh and salt, W. G. = water gas.

TABLE NO. 3C.

Materials of Construction of Water Ends.

Reciprocating Steam Pumps—Centre and Outside End Packed Patterns.

Service	Body	Lining	Plunger	Centre packed pump rod	Packing glands and plunger bushings	Valves	Valve seats	Valve stems	Valve springs	Valve guards
Boiler feed.....	C. I.	None.	Chilled C. I. or cast steel.	Tobin bronze.	Bronze or bronze bushed.	Bronze.	Bronze.	Bronze (if any).	Phosphor bronze.	Bronze.
Condenser water (F.&S.)	"	"	"	"	"	Rubber comp.	"	Bronze.	"	Hard brass.
Oils	"	"	"	Hammered steel.	"	Bronze.	"	"	"	None.
Coal gas tar....	"	"	"	"	C. I.	Steel balls.	C. I.	None.	None.	None.
Water gas tar ..	"	"	"	"	"	Bronze.	Bronze.	Bronze.	Phosphor Bronze.	None.
Ammoniacal water.....	"	"	"	"	"	C. I.	C. I.	Steel.	Steel.	None.
Separator or circulating water (W. G.)	"	"	"	"	"	Bronze.	Bronze.	Bronze.	Phosphor bronze.	None.
Drips.....	"	"	"	"	"	C. I. or bronze.	"	"	"	None.
Hydraulic.....	"	"	"	Tobin bronze.	Bronze or bronze bushed.	Bronze.	"	"	"	None.

NOTE :—Hammered steel steam rods should be used when practicable. Bronze should be U. S. navy composition (88 per cent. copper, 10 per cent. tin, 2 per cent. zinc). C I. = cast iron, F. & S. = fresh and salt, W. G. = water gas.

Plunger and Ring Pattern.

For condenser water, oils and drainage services, see packed piston pumps, Table No. 3B. For fire service, see specification issued by the National Fire Protective Association.

TABLE NO. 3D.

Power Pumps.

Reciprocating Pattern.

For materials of construction of water ends see Tables Nos. 3B and 3C.

Power Pumps.

Centrifugal Pattern.

Service	Case	Lining	Impellers	Shaft	Type of packing boxes	Packing glands and shaft bushings	Bearings
Boiler feed.....	C. I.	None.	Bronze.	Steel bronze covered.	Double depth with liquid sealing connections.	Bronze.	Separate ring oiling.
Condenser water (F. & S.).....	"	"	"	"	"	"	"
Ammoniacal liquor	"	"	C. I.	C. I.	"	C. I.	"
Separator or circulating water (W.G.)	"	"	"	"	"	"	"
Hydraulic.....	"	"	Bronze.	Steel bronze covered.	"	Bronze.	"
Drainage.....	Materials should be selected according to the nature of the liquid handled.						

NOTE:—Bronze should be U. S. Navy composition (88 per cent. copper, 10 per cent. tin, 2 per cent. zinc).

C. I. = cast iron, F. & S. = fresh and salt, W. G. = water gas.

Power Pumps—Rotary.

Rotary pumps are built of materials similar to the one listed for centrifugal pump, except that pump cases should be lined with bronze when built for handling salt water; and all parts should be of cast iron, cast steel or steel when built for handling oils, tars, ammoniacal liquor or alkalies. When built for handling acids, all parts should be either of acid bronze or protected by same.

The materials of construction of the remaining types of pumps noted in Table No. 2 should be influenced by the character of the liquid to be handled except where mechanical reasons might alter their practicability.

The next paper is

CULTIVATION OF FRIENDLY RELATIONS BETWEEN THE PUBLIC AND THE LIGHTING COMPANIES.

BY MR. W. J. CLARK.

Mr. Clark then read his paper as follows:

CULTIVATION OF FRIENDLY RELATIONS BETWEEN THE PUBLIC AND THE LIGHTING COMPANY.

I believe it goes without saying that the Lighting company occupies a unique position in the commercial world, by reason of the fact that the commodity which it sells is an intangible thing, and the method of measuring its product is more or less incomprehensible to the average user. Its position is also peculiar because unlike almost any other commodity which enters into general consumption as a factor for comfortable living, its product is, so to speak, on tap, and may be used at will without reckoning or hindrance,—a condition which naturally leads to its thoughtless and wasteful use. It is much as if the average citizen were allowed transportation on the street cars without demand being made for the immediate payment of fares, which condition would mean the presentation of a bill at the expiration of a month which would be of an unexpectedly large amount. The habit of riding would become a matter of moods rather than of necessity, and would lead to extravagance. Patrons of the trolley car would be astonished at the end of the month at the size of their transportation bills.

Thus commercially, the lighting company labors under a great disadvantage, owing to the nature of the commodity which it dispenses, and because of the unlimited temporary credit of which the consumer may avail himself. Another factor which the lighting company has to combat, and one which has been borne in upon anyone who has spent any length of time in the service of a lighting company, is that in the mind of the average citizen there is a deep rooted prejudice

against his kind, an innate feeling of distrust, and one of long standing. That this feeling does exist, cannot be gainsaid, as is evidenced by the comment that is made by the average citizen whenever the lighting company and its bills are discussed. The average man who will talk sanely and rationally upon any other subject seems to lose his balance when discussing his gas bill.

It is a vital matter that this feeling should be uprooted and eliminated, and upon the means of doing this it is worth while spending a lot of thought, time and money. How to overcome this prejudice should be the daily study of those handling our product, and their aim should be the establishment of a feeling of confidence and good will in the place of distrust and dissatisfaction. I firmly believe that this can be accomplished, but it will be a matter of earnest, patient, educational work, not only with the public, but with our employees.

Let us look for a moment at some of our possible shortcomings, the results of which go to create and maintain this feeling of dissatisfaction. We must keep foremost in our minds the fact that we sell not only the commodity generated at the plant, but its valuable contingent, service, and we must impress this indelibly upon the minds of our employees and our patrons. Our standing with the community with which we deal, depends largely upon the kind of publicity we get, and, as someone has aptly said, "One man on the block makes public opinion." We all realize that the voice of the one dissatisfied consumer who finds fault with our service is heard, and his claims, whether just or unjust, are accentuated because of the fact that his hundred and one satisfied neighbors take it for granted that good service is their due, accept it and say nothing about it. In our own interest we should carry on a campaign of favorable publicity through all legitimate channels, and this campaigning must necessarily be largely an educational one, and it is important that we school our employees to become leaders in this work. How many

of the employees of a lighting company who come into direct contact with the consumer, and through whom we must necessarily transact our business with the public, are capable, or, what is more to the point, interested enough to put up a logical argument on behalf of the company, and meet intelligently the assertions of a consumer as to the forcing of air into the mains, the maintenance of unnecessarily high gas pressures, the statement as to the general inaccuracy of meters, and the giving of a satisfactory explanation as to the measuring and recording devices of our appliances. Probably very few of the ordinary run of employees are at all familiar with the fundamental laws governing gas distribution, the construction of a meter, the channels through which the gas passes, and how the measurement is transmitted to the dials. The place where our work must begin is at home, and the expense of this work should be a departmental charge in every gas company.

Progress clubs should be formed and put under the direction of competent, intelligent, sympathetic men. The meetings of these clubs should be made interesting, and object lessons should be graphically given by means of lantern slides and blackboard illustrations. The men should be taught tactful methods of approaching consumers and handling their many complaints. This educational work should not be done in a spasmodic or haphazard manner, but should be persistently carried out. We must begin way down the line. Take, for instance, the transmitting to us of our patrons' communications. I have always contended that the telephone service of a lighting company should be carried on by intelligent, well informed and qualified men, never, as in many cases, by untrained boys. For this position I would select an employee who possesses first of all, a pleasing, well placed voice, and one trained to enunciate properly. We have all had our experiences with the poor telephone service, and have had our patience tried by the incompetence of telephone clerks, whose rasping tones or inarticulate mutterings have

racked our nerves, and whose communications are so unintelligible as to make it impossible to gather any sense from the message. Telephone messages, we must remember, often come to us from very busy people, who have no time to repeat over and over again their message to some incompetent clerk, who keeps calling "What" over the wire. If you will place yourself in the position of such a consumer, you will have forcibly borne in upon you one of the reasons why our service is complained of, and how much this kind of service militates against the building up of good feeling toward the company. In the matter of communications, we might take up next the mail, and ascertain how much of it and in what manner answered. I believe that every communication should receive acknowledgment of some kind, and the safe way is to immediately acknowledge receipt of the communication by mail, as there are many channels in the handling of a large business, through which a verbal message might miscarry, and if it does, the consumer is entirely in the dark as to what has become of this communication until the shopman, perhaps after much delay, reaches him, or, in the event of the ticket being lost or mislaid, may not reach him at all. This leads us naturally to the matter of the supervision of the carrying out of the orders which emanate from the front desk. Take the information or complaint desk, for instance. The man presiding here can do much to make or mar us. He should frame his orders concisely, legibly and intelligently, and have the executive ability to properly distribute them in channels which he knows are effective and which will bring satisfactory reports of their completion. As to the personality of this man, first of all, he should be of prepossessing appearance, of affable manner, and well informed as to all of the details of the business. This man must be something more than a mere clerk, and any promises made by him or his assistants to the public should be religiously carried out, for no matter how pleasing his manner, if the promises which he makes to the public are not promptly and carefully fulfilled,

either through failure of shop or office employees or methods, his position is stultified and his assurances to the consumer are not given credence. The natural channel for orders, emanating from this man's department would be to and through the shop, and this brings up the matter of this part of the carrying out of the work.

The shopman is the one upon whom we must rely to make good the front desk man's promises. Is the average shopman qualified to do this, and how many of us make it our business to see that he is? Is his work purely perfunctory? Has he any real interest in it? Here is a fine field for our educational work, and a tremendously broad one, now that our commodity enters so largely as a factor into up-to-date comfortable living, and its uses have become so varied. These men should be schooled on broader lines than heretofore. They should have a general knowledge of the distribution end of the business. They should know something of the construction of gas appliances which are used for lighting, heating and cooking, and their efficiencies and operations under various conditions. They should have some fundamental knowledge of what makes for proper light diffusion. They should be taught the methods of adjusting mantle lamps of the various types which are now in such general use, for I believe that many of the complaints we receive are not so much in criticism of the quality of the commodity which we sell as of the methods which obtain in its distribution. We should, I think, bend our energies toward finding out how well grounded these complaints may be, and if we find that they are warranted, look up the means of minimizing if not eliminating them. Knowing that the candle-power is up to the standard, that proper pressures are maintained, and that the appliances which we install are efficient, let us convince our patrons of these facts by good logical reasoning, and if there are shortcomings in our service let us look them up and remedy them.

I think there is more or less misunderstanding brought about by the giving of orders or lodging complaints by the

consumer with our outside men such as collectors, indexers and fitters. These men should be provided with printed forms in pads, with blank for name, premises, etc., and a place for noting the particulars of the consumer's request, and these should be turned in daily with returns, work slips, etc. We often have word sent in by mail saying that messages have been sent which received no attention from the office, and find upon questioning the consumer that he has delivered his message to an employee on the district and he (the employee) has neglected to make any report of it. I think some such method as I have suggested, that is, of having printed forms in the hands of the district employees, would remedy this and help in eleminating misunderstanding as to the company's position in the matter of attending to complaints. The day that the shopman's efficiency was determined by his ability to set a meter and read an index is past, and if he is one who is contented to stop here, he is not, at this day and date, a competent man to satisfactorily do our work and deal with the public. If he has the capacity to absorb such up-to-date knowledge as he should possess, he should be taken in hand and taught. The gas company manager has a task before him and no easy one, if he is to successfully meet the competition of other lighting methods, and he must go beyond the mere placing of flat flame burners on consumers' fixtures. The gas company manager now sanctions the spending of thousands of dollars in changing these old time lighting devices, but as a rule he leaves it to some lamp manufacturer, seller or agent to maintain the efficiency of the more delicate and important lighting device, the incandescent mantle lamp, in which as a rule, the seller has no interest after the lamps are installed. In view of the fact that the gas manager is willing to spend much money on the older type of burners, looking to the betterment of lighting efficiencies, is it not logical that he should go into the field of maintenance of this new light giving device, particularly in view of the fact that the electric lighting man is

in the field, continually improving his appliances and promoting their efficiencies.

It seems to me that a field in which the gas men might work great advantage to himself and to his patrons is in the supervision of the initial equipment of lighting fixtures, seeing that properly constructed burners are installed. As it is done now, by the contracting fixture man, hardly any attention whatever is given to local conditions or requirements, or with any view to economy in the use of our product. Ordinarily this initial equipment will consist of lava tips of uniform and unnecessarily large size, which are placed on each and every outlet in a house or apartment without any regard to elevation, pressure or housepiping conditions. It would seem as though it should come within the province of the gas man to remedy this, inasmuch as the first user of these burners is likely to file a high bill complaint upon receipt of his first bill. The first installation of burners is frequently a waste of time and material by reason of the fact that being put on by the contracting fixture men they are not only entirely inefficient in light giving quality, but are often the cause of broken glassware through defective flame orifices, which means that the lighting company starts its dealings with the consumer under most unfavorable conditions.

This brings up the question as to what degree of intelligence is used in making the substitution of other burners for these defective ones. I once came across the burner records of one company, in which no burners smaller than No. 8 Brays had ever been purchased by the Company for installation on consumers' fixtures. Upon asking the manager what he would do in case of a high bill complaint, and wished to reduce the consumption of gas and satisfy the consumer, he said his men were instructed to tell the consumer to turn the burner down. An instance where a school of instruction would not be amiss.

In this same district the fitters are in the habit of carrying burners around loosely in their pockets. Out of curiosity I stopped one of these shopmen on the street one day and asked

him to show me some of the burners. When he took them out of his pocket, the burners were filled with loose tobacco. You can infer with what degree of intelligence burner orders are executed under such conditions, and what amount of satisfaction is likely to accrue on the consumers' part. Is not some of the prejudice of which we complain as being innate, of our own making? It certainly will pay us to find out, and if so, apply the remedy. The cost of the educational work necessary to bring up the efficiency of our employees to a standard which will win expressed approbation from our patrons, should be a secondary consideration.

THE PRESIDENT: Gentlemen, Mr. Clark's paper is timely. Is there any discussion?

MR. CHARLES M. COHN: We are particularly fortunate in having the views of Mr. Clark on the "Cultivation of Friendly Relations between the Public and the Lighting Company." He is eminently qualified to discuss the commercial side of the gas business. When his paper reached me with a request that I be prepared to discuss it, I immediately obtained the views of the various officials in the commercial side of the Baltimore Company, but on account of the shortness of time, I will read a few extracts from the paper which I consider the best of the three or four sent me:

"While the nature of the business is such that the two things a lighting company is selling—energy and service, are intangible, its compensation is to be found in the fact that there are few businesses which offer so many points of contact between the customer and the company, which may be utilized to bring about a realization of the value of the corporation to the individual, in other words—good will. To promote good will, it is essential that cordial relations exist. Cordiality is a mutual relation. The first step in its direction is courtesy. The Japanese put the Golden Rule this way—"You cannot be comfortable yourself unless you make those around you comfortable."

Probably eighty per cent. of the customers of a lighting company visit its offices once a month to pay their bills. Here is a fruitful field for the cultivation of friendly relations. A courteous greeting at the door and an intelligent direction to the proper place to have their business promptly dispatched, goes a long ways. Demonstrations of the value and economy of the product sold will bring to the attention of the customer some of the things he is enjoying or missing at his home. Various gas saving appliances both for cooking and lighting, devices of recent improvement which would possess the attraction of novelty as well as usefulness, would interest him and impress on him the fact that the company expects to prosper through the quality of its service, that it is alive to the progress of the world, and that the results of the scientist working in some research laboratory are made of practical benefit to him through their application by his lighting company.

If a community were small enough for the manager of a lighting company to meet and talk to all of his company's customers, the cultivation of friendly relations would be simpler. But he must talk through a megaphone, so he uses the newspapers or bill boards or illuminated signs. The value of the newspaper lies only in the fact that it contains news of interest, but in the fact that it has a circulation system. Every gas company has a circulation system superior to that of any newspaper in its community, and it also has 'news.' It usually has a directory of every house along its mains, consumers and non-consumers, and its cards show exactly the equipment and needs of each customer or prospective customer. It should also have facilities for printing, multigraphing and circulating, at small cost, frequent communications to its customers. With the explicit information of its files, it can avoid waste and duplication. For example, in the spring a letter might be sent to each user of a gas range who does not use a gas water heater. If this letter told that customer that he was saving money as well as labor, by the use of his gas range, and that a gas water heater would mean a further saving, and more convenience, he would not only be interested in a water heater,

but he would realize that here was a corporation that knew what he needed, and that *it wanted his business.*

Similar communications could be sent in the fall to those customers having gas ranges and water heaters telling of the advantages of a furnace water heater. The use of monthly bills, which have a circulation greater than any publication in a community, for straightforward, earnest messages is perhaps the best and least expensive of all forms of advertising.

The time of the last payment on an appliance offers an opportunity for the cultivation of friendly relations. When a man applies for gas, a copy of the record is usually sent to the new business department, and a solicitor calls and sells him a gas range. The customer makes monthly payments for perhaps ten months after that time. It would cost two cents to send him a letter acknowledging the completion of the payment and asking if the service is satisfactory in every way, and inviting his criticism. Such a personal letter would give the customer the idea that his business and his good will are valued by the company. Multiply this by the number of ranges sold in a year and you have ten thousand people convinced that the company is endeavoring to please and to satisfy them, a considerable factor in any community."

These remarks will give a fair idea of the feeling of the organization in Baltimore in the matter of preservation and cultivation of friendly relations with the public.

The cultivation of friendly relations between the public and public service corporations is nothing more than applied common sense. Everyone conceded the desirability of such relations. The discussion of this question usually results in very general unanimity of opinion. Methods of more effectually meeting the requirements of the public, are however, suggested and often put into practice. The days of an arbitrary and dictatorial attitude on the part of the public service corporations have passed, and it is generally recognized that the only proper and successful way of conducting business is along the lines of the "Public be Pleased" policy. This means not only the giving of due and courteous consideration

to all customers, but also that the employees should command the respect and confidence of the public. It is a mutual relationship, and cannot be maintained where either side is inconsiderate and without respect to the other.

In the conduct of the gas business, there is no better means of ascertaining the shortcomings of the service than by giving very strict attention to every communication, whether written or oral, passing between the consumer and the company. This serves as an index to the business, discloses irregularities and defects, and if systematically and continuously carried out, tends toward the betterment of the service and the improvement of the organization. We should not be disappointed in not receiving praise for good work, but should gladly receive helpful criticisms.

A gas company properly fulfilling its functions is a very useful institution in any community. Its territory is restricted and success is dependent in a large measure on the disposition of the public it serves. It is fundamentally the public duty of a gas company to keep its service up to the highest practical standard and to charge a reasonable price for its product.

Friendly relations are promoted by the educational work carried on by many progressive gas companies. This has brought about the more economical use of gas for lighting purposes and has largely extended the use of gas for domestic and industrial purposes. There is nothing peculiar to the business of a gas company. Its methods can be readily understood and it furnishes three of the most important factors in everyday life—light, heat and power. To supply these efficiently and economically is the primary object of a gas company, and a company that fulfills its mission in this respect usually makes proper returns to those who have invested their capital in the business.

In conclusion, I was very much impressed with the extract of the discussion and the valuable information brought out during this Convention, bearing on the cutting down of costs of operation, that is, the various economical means suggested of reducing the cost of gas in the holder and at the burner.

It has occurred to me while listening to those valuable discussions, that many practical gas men fail to realize that in the present state of the art of gas making and gas distribution, the most important and perhaps the most potent single factor in reducing the cost of production and distribution is the volume of gas sold. It is the volume of gas sold that is doing more to reduce the ratio of operating expenses to gross income than any other factor. This brings into prominence the commercial side of the industry and should engage the earnest attention of the technical men as well as the commercial men. It has occurred to me, therefore, that a closer affiliation between the technical and the commercial sides of the gas business would be of great value to the industry. The apparent lack of close co-operation is perhaps due to the fact that each side has its ardent advocates and they are possibly too much engaged with their problems to realize that the gas industry after all, is engaged in for gain. The technical questions involved are extremely important in so far as they bear on the satisfactory and economical production and distribution of gas, but beyond the proper solution of the engineering and scientific features of the industry, scientific research work as such is not within the province of the gas industry. Consequently, considerable attention should be given to the advantageous development of the commercial side of the gas industry by the American Gas Institute. It may not be irrelevant to call attention to the fact that the American Gas Institute aspires to be recognized as *the authority* in all matters pertaining to the gas industry, and therefore, the commercial side of the business should have complete recognition.

MR. BRUNDAGE: I have a short discussion in this subject prepared by Mr. George W. Thomson. With your approval I will read it. (Reading)

It seems to me that Mr. Clark shows us that "Ignorance is the root of all evil." Now, the amount of time and study we give to this lesson depends on how much we want to foster our consumers' friendship. I think that as we study this paper we will realize that we have been over looking a great

opportunity, the opportunity to develop our business on present meters by the proper training of our employees.

The reason why there has been a development of public ill will in some cities is because of ignorance on the part of the public, and also on the company's part.

This is a wrong condition of affairs, and it will never be made right, if we fail to make the start.

Now let me ask that each of us upon our return home place a copy of Mr. Clark's paper in the hands of every department head, and then call a meeting of these department heads and outline a campaign of education and business building. Let each man at these meetings rise and talk about Mr. Clark's paper. Issue instructions to department heads that they must call a meeting, if only for half an hour, every week, of all men in their department. The meetings of the department heads should be held every week for a while and then once in two weeks. These meetings should in no way interfere with the evening meetings of Employees Associations, if you have same.

Our companies may have greater sales per meter if they will, and want it bad enough to pay the price. If they are unwilling to pay it means simply that they do not want the increase as much as they want other things in the world. We should desire our customers' good will, which means increased sales, with such intensity that every other thing becomes unimportant.

When we consider some of the Western companies, whose sales per capita are far above the average, we find a company that has devoted all its thought and energy to becoming the foremost company in this respect. Its plan is to serve its customers in their homes by the house to house method with well trained service supervisors. Such a company is willing to pay the price for rendering good service, and building up and holding the good will of the public. Its up to ourselves to attain similar results.

Mr. Pettes: Mr. President, I think Mr. Clark has left very little to be said on the subject, but I want to emphasize

one or two points that he made. I think he places before us an old matter in a new light. He has drawn some very good comparisons, especially where he makes the comparison of riding on the street cars and having a bill presented after the riding is done, as contrasted with our methods of selling gas. I think the order clerks should be very carefully selected; they ought to be men, as he says, of good appearance, who thoroughly understand the business and have also a disposition to be able to question people and draw out all the facts from them without irritating them, either over the phone or in person. The company will not only save its customers a great deal of irritation if an order is taken right, but it will also save the distribution department a good deal of money. I think an order well taken is generally apt to be executed on time, that is without delay; whereas, if it is once hung up, it takes a special effort on the part of some man to see that it goes through. Another thing, I think that these men should be careful about making promises, unless they are pretty sure that they are to be executed, they had better tell the customer the length of time it is likely to take to have the order filled. I think that employees should be given all the chance possible to get educated in the business. The old plan was to try a man out, possibly for a month or so, and then if he did not fit, get rid of him. I think the modern plan is, after you get hold of a man that you think has some ability, to give him ample time in which to learn the business and also spend some time on bringing him up to the standard. I do not think that you should select men simply because they are out of a job. We had better wait a little while, and have a waiting list of good men of good appearance who are likely to go ahead in the business and to be of sufficient ability to work higher.

THE PRESIDENT: Are there any other gentlemen who would like to discuss this paper?

MR. NORMAN MACBETH: It would seem to be difficult to add anything to Mr. Clark's paper, and there seems to be little opportunity for criticism; but there are some two or three points in it that I should like to emphasize, perhaps partly from

the standpoint of a consumer. The comparison here between the trolley road charging up a bill at the end of the year might be carried still further and compare those rides to the taxicab charges for the individual rider. Undoubtedly taxicab charges would appear very much more reasonable. There are still some gas companies, however, who continue to send quarterly bills and that is almost as bad as a yearly trolley charge. A five dollar gas bill is not nearly as bad as a fifteen dollar quarterly bill and consumers generally, while knowing it is for three months, some way seem to overlook it. The matter of ill feeling against gas companies is nearly universal and it would seem, as Mr. Clark says, that the prejudice must be overcome not only with the public but through the work of our own employees. We want employees who are able to put up a logical argument to the consumer, and there isn't any other way of bringing up that logical argument unless the employees get together at various times and learn something about the business, and know the ideas of the management and along what lines they are working. Individual opinion will very rarely smooth those matters out, because the consumer, getting an individual opinion from a fitter, or from a man in another department, sometimes finds these opinions so different that he says, "Oh well, I guess they are putting it over me anyway." In the matter of "one man in the block makes public opinion," that is true, and I believe that the one man in the block is the man who has a slow meter. If there is any one thing wrong with gas meters, it is due to the fact that they are too good. If they were a little more dyspeptic and had to be looked after oftener, there would be less difficulty, but gas meters are ordinarily so good that some companies leave them in for fifteen or twenty years without looking at them. They do not know when the meters go wrong. It costs something to look after meters. There is a certain loss to a meter that is slow. If the amount lost by the slow meter is not sufficient to offset the charges of taking care of it, it is not looked after. I believe there is no one factor which will so upset a consumer as a slow meter. A neighbor with a slow meter,

will compare his bills with those of neighbors whose meters are more nearly correct. I have had personal experience in a number of cities as a consumer. I remember one city where they used to advertise "Write, phone, call and see us," and you could do it all, and do it four or five times, and never get anything for it. I remember, another company, about which the statement had been made that if you had a complaint and wrote it on the back of an envelope, or a scrap of paper, and dropped it in the street, somehow or other that complaint would be attended to the next day. That is the difference in service and taking care of public opinion. A great many gas companies I believe are still using open flames, because they need consumption. Now we ought to know that we cannot sell five dollar gas. It would be very nice if we could sell five dollar gas if we could make it at a cost such that it could be sold ordinarily for one dollar; we would make a whole lot of money if the people would continue to buy it. If we could sell 20 cent gas, you know you could sell a great deal more gas than you can now as a dollar; but to sell 20 cent gas, it would be necessary that we could buy our coal and other supplies at much lower prices. A salesman who is unable to go out to-day and sell industrial gas at a dollar and a half because his gas is too high priced, does not hesitate to permit the consumer to take a fixture with open flame burners, when as a matter of fact if the gas rate in that town happens to be a dollar, the consumer is going to pay five dollars per thousand on the basis of illumination. The question of the first cost of fixtures, lamps and burners is very little if you capitalize the efficiency of those burners. There are very few lamps, even the most expensive on the market, which will not be covered by those savings in at least one year's use, and certainly many times over during the life of the lamp. If there is one thing that has been bad for our business it has been the department store burners which the gas companies have countenanced, and allowed stores of that character to sell. The electric lighting man is in the field continually and improving his appliances and promoting efficiency. I think there is still an opportunity

for the man to take up that line of business and be credited with a certain amount of initiative. It surely would look a good deal better than to be driven into it at a time when perhaps his competitor has drawn his lines so sharp and tight that there is very little chance for him to get in. High bills and complaints cannot be settled by using smaller burners. High bills and complaints are rather due to the kind of gas as much as to the price of the gas. They are due simply and solely to the fact that you are not giving value for the money received, and any number of complaints have been straightened out by actually increasing the bills, by giving considerably more value for the money received under those increases. Mr. Clark closes by saying: "Is not some of the prejudice of which we complain as being innate, of our own making?" I believe it is all of our own making; I don't think there is any doubt about it. The points he has outlined have to do entirely with better service, with educating the employees, with spending money for maintenance of meters, getting better grades of men and all that kind of thing, but the best thing about it is that it is a good investment. There isn't any one thing in the business that will do as much to improve your relations with the public and increase your sales. If you could buy coal for half the price you are buying it now, and if you sold gas at the price you are selling it, it would be a mere bagatelle compared with this other consideration. I believe the opportunities on these lines in the gas business to-day are many and the opportunities in the gas business are synonymous with the opportunities in the very best kind of business that we can pick out anywhere.

THE PRESIDENT: Are there any more remarks?

MR. SEARLE: I don't want the impression to go abroad that this paper carries that we ought to reduce every gas bill. About the worst thing that we can do, if a consumer is using all he requires of our service, is to deprive him of it. He is getting value received and it is up to you to make the argument that Mr. Macbeth made, to prove to him that he is getting value received. We have known men who would go out and

say "Why I can account for that. Your cook is wasting gas." I wouldn't say anything like that. I would say "The efficiency obtained by your cook on that stove is saving her so much time that you can dispense with another servant." In another case the husband was a crank about hot water. He now says we are the greatest benefactor in Rochester. He wants hot water to shave with, and to fill hot water bags, and he is the "Man of the house." He never complains about the gas bill. We are selling about $100 worth of gas there every year instead of thirty dollars. If I am not mistaken we have got the cook on our side. This cook can use eight or ten dollars' worth a month, in a family of two if she will stay with them. We have ten thousand consumers in Rochester. It is not a question of the size of the gas bill at all but of the service. If we know that the consumer is getting value received, the entire argument put to that consumer is to prove to him that he is getting value received and we don't want to cut his bill. The moment you cut his bill we are punishing him and he does not want to be punished. In Rochester we have a florist who put in his corner store a prismatic glass equipment and cut his electric bill from $75 a month to $20. They sold him that prismatic glass front to his store on the theory that he would save in the amount of electric current. I personally saw the man and told him he could afford to pay $75 a month for electric current, and as long as he had paid it for years, he was not out anything, and the difference between that amount and his present bill could be put into electric signs. His store would be lighted until 1 A. M., and he would do seventy-five dollars' worth more business. He took the suggestion and went back to his original consumption. We don't want to save him money. He wants to sell flowers and we help him to sell them and he knows it is helping him to sell flowers.

We have two large grocery stores. The gas man is a competitor with the electric man. The gas man tells one of them that he can get a better light with a single unit reflection burner by putting it down near the counter. The store is on a prominent avenue and every one that passes in an automobile

thinks that the store is closed because it is so dark above. The other store is lighted with electricity and this man's place is so popular that he can do more business in it than the other man can in the other one. He says he would not take gas for a gift; he is going to have his place lighted up if it costs five times as much. The gas man went to him on the theory that he could save him money on light but that man doesn't want money saved on light at all; he wants to make money on sales. Speaking of telephone service, the telephone is being introduced so fast and men, women and children are so taught to avail themselves of its benefits, that the telephone business has increased at the rate of 100,000 messages to 1,000 in ten years, and still there are lighting companies who have only one phone. Now if you had a hundred times as many customers in your place as you had ten years ago you would certainly have more clerks; so there is more business you could do if you had more telephones than you are using now. Another thing about the telephone is to be sure that the party who telephones to the office knows the man or the girl he is talking to, so that he can get that person the next time when that conversation is continued—and not be passed along so that he talks to a different party each time. I want to make mention again of the question that was raised about open flame burners versus Welsbach. There is no reason in the world for putting a Welsbach light in the front of a furnace to save a few feet of gas. It isn't a question of five dollars per thousand feet of gas, but much more, for repairs, or no illumination at all, and possible damage.

Mr McDonald: In line with Mr. Clark's paper, I want to say that in our city we have a system by which our customers do not come to the office. We sent out recently circulars reading about like this: "Complaints wanted. Is our service to you entirely satisfactory? If not, we want to make it so. Write on the stub of your bill any complaint that you may have and we will attend to it." Well, we get some profanity and some said the bills were too big, but we got four or five hundred cases of consumers who for a long time had been

putting up with something that they did not know could be remedied, and we could remedy it readily and get an increase of the bill next month, which would more than pay for the cost of it. I think an easy, satisfactory way by which a consumer can complain to you is a mighty good thing to have.

THE PRESIDENT: Any more remarks?

MR. SEYMOUR: I make a motion that Mr. Clark's paper be printed, and sold at so much per hundred or thousand. I believe there are a good many people here who would like to see it distributed.

MR. MCDONALD: I second the motion.

THE PRESIDENT: Who is to do the printing?

MR. SEYMOUR: The Institute, and then sell them to the members.

THE PRESIDENT: It has been moved and seconded that a sufficient number of copies of Mr. Clark's paper be printed by the Institute for sale to the members. Are you ready for the question?

The question was called for and the motion carried.

MR. NORMAN MACBETH: I spoke generally of mantle burners versus open flames, but undoubtedly at furnace doors and in some storage cellars there is a good deal of breakage. That represents, however, a very small percentage of the total number, and the best figures I have been able to find of the percentage of mantle burners in use on outlets does not exceed, in this country, 15 per cent. In Germany it is 98 per cent., in Canada 60 to 65 per cent., and in towns in England it is away up.

THE PRESIDENT: Does Mr. Clark wish to make any remarks in closing?

MR. CLARK: I will not take any further time of the convention. I want to thank the members for the interest they have taken in the paper.

THE PRESIDENT: They have all taken great interest in it.

A vote of thanks to Mr. Clark for his paper was then duly carried.

THE PRESIDENT: The next paper is

BRICK, CONCRETE AND STEEL HOLDER TANKS.

BY MR. H. W. ALRICH.

MR. ALRICH: Mr. President, the time is so short and the paper is long, so I would rather yield to the discussion.

THE PRESIDENT: Gentlemen, Mr. Alrich is in the mood of saving time. You may consider his paper as read by title.

BRICK, CONCRETE AND STEEL HOLDER TANKS.

Since the inception of the gas industry there have been holder tanks constructed of many types and many materials. While there are still tanks occasionally built of unusual design, the practice of the present time is represented most frequently by two types of tank and three materials. Tanks above ground and tanks below comprise the types while brick, concrete and steel are the materials. However, these materials are not regarded as being all suitable for either type of tank. Only very unusual conditions could furnish sufficient reasons for placing a large steel tank entirely below ground and no brick or concrete tank of large size has ever been built without a backing of earth. Hence we may state the prevailing practice to be confined to either steel tanks above ground or masonry tanks below.

The construction of the earlier gas holders required no origination in tank design. Adaptations from existing practice in cisterns were sufficient. An increase in the size of holders accompanied the extended use of gas and the construction of the tanks was successively identical with the several types of water tanks of corresponding size.

Until the 70s the tanks built in this country did not often exceed 100 ft. in diameter nor 30 ft. in depth. Brick were as well made as they are now and were very much cheaper. Bricklayers worked 10 hours for $2.50. At the same time wro't iron plates of the thickness necessary for tanks of suitable depth, more than 60 ft. in diameter, were not being manu-

factured anywhere in the world. The remarkable skill with which cast iron was then applied to structural purposes testifies to the high cost of wro't iron construction at that time. Under such conditions the standard tank in this country became a brick pit constructed either entirely below the surface of the ground or with the earth embanked against its outstanding portion. They were generally located upon a site where the ground formation was favorable.

It still sometimes happens that when planning a holder a site may be selected the geology of which is suitable for the type of tank it is desired to build. More frequently, however, we are confronted by conditions which permit little freedom, and dictate the question of the kind of tank there shall be built upon that ground. The different formations that are encountered are too numerous to classify and often too composite to describe. Among those of frequent occurrence we may mention sand, clay, rock, hardpan and mud. Given any one of these conditions or a combination of them and the advocates of brick tanks will present their claims.

It is doubtless proper to consider the advantages of any type of tank in favor of which there may be a local sentiment, but the writer is convinced that there is one type of tank superior to all others and preferable for almost any conditions to be found in the United States. The brick tank seems to be regarded as the criterion of prudence and conservatism, but an examination of these claims does not disclose them as being very well founded. Brick tanks are a survival of an era of non-theoretical engineering when the designing was done by the master mason with results which, while not dangerously bad, were not economically good. It is true that considerable mechanical reasoning was applied in the design of these tanks but this reasoning was not developed in connection with any definite theory of the behavior of the material and there resulted no rational mathematical determination of what and how much the tanks were expected to withstand. Forty years ago some formulæ were devised for computing the resistance of a masonry tank to the bursting pressure of the water. Very

strangely, however, the method does not appear to have been extensively applied until engineering knowledge had advanced past the point where the assumptions necessary to the formulæ were possible to accept.

All engineering structures are subject and liable to the action of forces tending to destroy them. In addition to providing for the proper resistance of those forces a structure is intended to withstand there must also be anticipated those other forces that may be circumstantially exerted against it.

When force is applied to a structure there follows as a result of the elasticity of all materials, a change in the dimensions and a bending of the component parts. The consequence of these deformations is a distortion of the geometric form of the structure as a whole.

If the applied force be continuously increased the deformations will correspondingly increase until the limit of elastic behavior of the material is reached when failure must occur. The elastic properties of all materials commonly used in engineering structures have been extensively investigated for the purpose of establishing the relation between the extension and compression of the substances and the forces whose effects these deformations are. Thus if the forces to which a structure will be subjected and the elastic properties of the materials are known we may, with reasonable accuracy, foretell the nature and amount of the deformations. Conversely, if we observe the nature and amount of the deformations we may compute from them the forces acting upon the structure. Or, disregarding entirely the forces producing them the deformations of a structure may be accepted as an index of its safety.

The distribution of the force applied to a structure among its component parts is somewhat independent of the amounts of material they severally contain. The distribution is influenced more directly by the forms of the parts and the manner in which the force is applied to them. If the amount of force applied to a structure be considerably increased, there will usually result a change in the manner of distribution.

Hence, when designing the elastic behavior of a structure must be investigated to determine the extent to which each component part participates in the work of resistance.

This investigation of the effect of force upon matter, or, in other words, of loads or pressure upon a structure is the theme of analytical mechanics. When applying this science to designing we have principally to discover the stress or amount of force exerted against each component part of the structure and the relation of this stress to the strain, that is, the shortening or elongation of the component part caused by the stress.

Since the 70s many brick tanks have been built in this country approximating 185 ft. in diameter and 42 ft. in depth. The stress conditions existing in a tank of that size will now be considered.

When investigating the strength of a tank, the force we have principally to consider is the effect of the retained water. This hydrostatic pressure produces a state of stress in one of the simplest forms. It is a force acting outward, normal to the surface and uniform at all points around the entire circumference. If the wall were perfectly elastic it would become infinitely thin. Thus the nature of the stress is seen to be pure tension, though if the tank be other than truly cylindrical there will be additional stresses induced by the bending of the wall as the hydrostatic pressure tends to correct the circle.

The resistance of the tank wall is exerted against the internal bursting pressure in two ways and *two* only;—first, the resistance of the material to the circumferential stretching, and second, the adhesion of the annular bottom surface of the wall to the foundation. This adhesion to the foundation results in a restraint upon the lower part of the wall, preventing it from expanding in diameter in obedience to the internal pressure. Practical considerations always require a greater thickness at the top of the wall than that necessary to resist the tension. This excessive section materially reduces the diametral expansion at the top. It is similar in effect to the

restraint exerted upon the bottom of the wall by the foundation. An exaggerated representation of the elastic deformation of the wall is shown in Fig. 1.

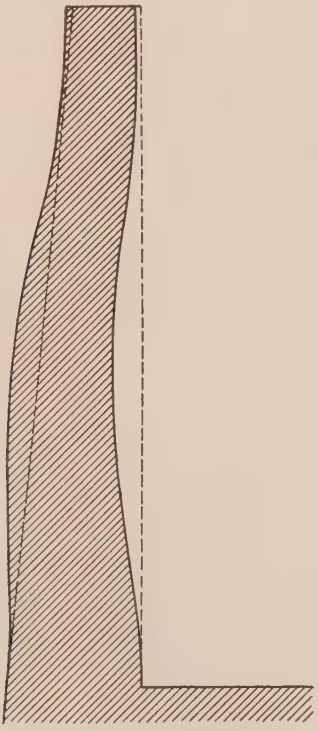


Fig. 1

Before computing the necessary wall thickness it is first necessary to determine the distance above the bottom at which the restraint of the foundation ceases to be effective. The exact determination of this distance would involve much calculation. However, with the proportions obtaining in holder tanks this may be taken as a height lying within that on which the total *circumferential* hydrostatic pressure is equal to the resistance to shearing of the bond of the tank wall to the foundation. As this height is evidently a function of the wall thickness an assumption must be made.

It will be taken at 12 ft. making the depth from top of tank to plane of maximum ring tension 30 ft. The shear consequent upon this assumption will now be investigated.

Let,—

D = diameter of tank = 185 ft.

h = depth to plane of maximum tension = 30 ft.

H = depth of tank = 42 ft.

S = tension in layer of brickwork 1 in. high.

T = thickness of wall in inches.

U = permissible unit tension

V = pressure on 1 in. of circumference 12 ft. high.

w = weight of water per cu. ft. = 62½ lbs.

Then,—

$$V = \frac{h + H}{2} \frac{w}{144} \times 12(H - h) = \frac{30 + 42}{2} \times \frac{62.5}{144} \times 12 \times 12 = 2{,}250 \text{ lbs.}$$

This pressure of 2,250 lbs. must be resisted in shear by a sectional area of the masonry bond 1 in. along the circumference and having the thickness of the wall for its other dimension. The writer does not know of the resistance of masonry bond to this form of stress having been experimentally determined. However, judging from the ease with which brick may be loosened from the top of a wall of high class masonry, it is reasonable to consider in this connection the weight superimposed upon the lowest course of brick. In the case of a wall 42 ft. high, at 120 lbs. per cu. ft. the bottom brick would be under a pressure of 35 lbs. per. sq. in. If we assume the safe resistance of the bond to shearing to equal 100 per cent. of friction there is derived for the minimum wall thickness to resist horizontal shear 5 ft. 4½in. As we would anticipate the wall having a thickness rather greater than this the distance of 12 feet may be regarded as a conservative assumption.

Considering next the thickness necessary to resist ring tension we have,—

$$S = \frac{12D}{2} \times h \times \frac{w}{144} = 1{,}110 \times 30 \times 0.434 = 14{,}450.$$

Also,—14,450 = T U.

The solution of this last equation requires us to assign a tensional value to brickwork. All the recorded tests of which the writer has knowledge were made in compression. These with a variation of several hundred per cent. compel us to believe that brickwork is one of the most uncertain factors in engineering.

In the designing of the brick tank 285 ft. in diameter built at Manchester in 1909, the ultimate resistance was taken as 220 lbs. per sq. in. This is the value given by Trautwine for the "average ultimate tensile resistance of *brick*." The various compression tests have uniformly indicated that brick alone develops a higher resistance to crushing than bricks and mortar. This would seem to be necessarily true in tension though the writer finds no record of its experimental determination.

The numerous tension tests of 1 : 3 cement mortar indicate an average ultimate unit resistance of 175 lbs. Applying this value and 220 lbs. for brick proportionately to a vertical section of masonry there results 208 lbs. as the value of the combination.

The New York Building Code limits the permissible unit tension induced by bending to 30 lbs. If however, we avoid a charge of prejudice by solving for T with U = 100 lbs. there is derived 12 ft. for the required thickness of the wall at a point 12 ft. above the bottom. This would be unthinkable.

Of tanks approximating the size here assumed, the writer has observed two that were 6 ft. 6 in., three 7 ft., and one 8 ft. thick. If we solve our equation for U taking $\frac{T}{12} = 7$ ft. there results a unit tension of 172 lbs. or 83 per cent. of the probable ultimate. If the tank were slightly elliptical instead of perfectly cylindrical there would be an additional increment of tension induced by the tendency of the wall to correct its curvature when subjected to the hydrostatic pressure. This stress would be greatest at the ends of the axes and zero at four points between. The question may be raised as to wheth-

er this stress is important. It is certainly safer to investigate than to guess.

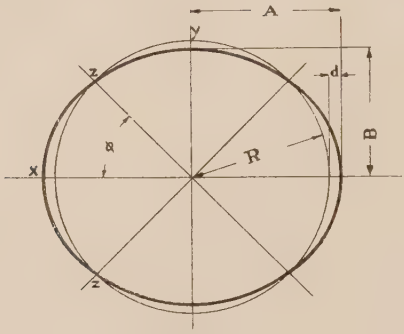


Fig. 2

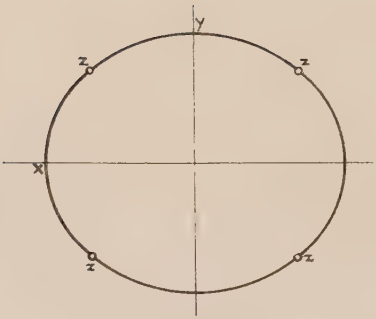


Fig. 3.

In Fig. 2 there is represented the elliptical curve to which the tank is assumed to have been built, superimposed upon a true circle of the same perimeter. We know from analytical mechanics that the tension in the shell of any vessel with a curved perimeter, in equilibrium is P R, in which P = the unit pressure at any point and R = radius of curvature at that point. From analytical geometry the radius of curvature at $x = \frac{B^2}{A}$, and at $y = \frac{A^2}{B}$.

The tension at x for equilibrium would be $P\frac{B^2}{A}$; the actual tension is P A. Likewise the tension at y for equilibrium would be $P\frac{A^2}{B}$, while the actual tension is P B. Evidently $\frac{B^2}{A} < A$ and $\frac{A^2}{B} > B$, hence equilibrium can only exist through a correction of curvature which indicates the existance of a bending moment, or internal stress in the wall must resist the bending.

As the radius of curvature of the ellipse passes through all values from $\frac{B^2}{A}$ at x, to $\frac{A^2}{B}$ at y, there is one point at which it $=$ R. Referring again to Fig. 2, if we imagine the ellipse to change in curvature until it coincides with the circle there is a point Z which undergoes no radial dislocation. Hence this is the point of constant curvature and no moment. Referring now to Fig. 3, we may conceive of the elliptical tank as a system of curved links, pin connected at the points Z, and acted upon by the uniform internal pressure P. Within the limits of conditions applying to this problem $\frac{A + B}{2}$ varies from R by less than any assignable difference. Also we may determine from the equations of the two curves referred to to the axes of x and y, that the angle ϕ does not differ materially from 45°.

Taking moments at x we have

$$P\left[(\sin\phi R)^2 - \frac{(\sin\phi R)^2}{2} - \frac{(A - \sin\phi R)^2}{2} - (\sin\phi R)(A - \sin\phi R)\right] =$$

$$P\left[(\sin\phi R)^2 - \frac{(\sin\phi R)^2}{2} - \frac{(R + d - \sin\phi R)^2}{2} - (\sin\phi R)(R + d - \sin\phi R)\right] =$$

$$P\left[0.5R^2 - 0.25R^2 - \frac{(0.086R + 0.586Rd + d^2)}{2} - (0.207R^2 + 0.707Rd)\right] =$$

$P(-Rd - 0.5d^2) =$ moment at x.

A similar process shows the moment at $y = P\ (Rd -$

0.5 d^2). Hence the moment at x is negative, tending to bend the wall outward and crack it on the inside. It will be observed that the moments at x and y differ only by the value of 2 P (0.5 d^2) and this term is plainly negligible. Hence the moment at either point may be taken as P R d.

Assigning a value of 1½ in. to d the moment at a depth of 30 ft. $= \frac{30 \times 62.5}{144} \times \frac{12 \times 185}{2} \times 1.5 = 21{,}700$ in lbs. With $\frac{T}{12} = 7$ ft., then the additional increment of tension $= 18.5$ lbs., making a total tension of 190.5 lbs. This is 91.60 per cent. of the probable ultimate.

There have now been considered the nature and amount of the stresses imposed upon the tank wall by the internal pressure and the deformation of the masonry from the resulting strains. It is evident that for a brick tank of large size there must be provided external assistance, for any such thickness of masonry as would safely withstand the pressure unaided is economically impossible.

In the designing of brick tanks the analysis originated by M. Arson, a French engineer, still seems to be universally applied. This analysis first appeared in a contribution by M. Arson to the "Societe des Engenieurs Civils." It was printed in their Transactions about 1870. Dr. Pole translated the article and Newbigging's works gave it currency. Though the world has constantly been moving since that day and experiment and reason have been joined to establish theory, masonry tanks are still *calculated* upon principles which, if followed to their logical conclusion, would result in a wall with twice the thickness at the top that it had at the bottom. "Calculated" we have said, not "designed" for it would appear that no tanks were ever so built. From this we may conclude that instinct has prevailed over reason and spared us the consequences of M. Arson's theory. The knowledge of the mechanics of materials in M. Arson's time was somewhat limited, hence his method disregards entirely the elastic

behavior of the material. By his theory the pressure is resisted by the moments of stability, taken collectively of a number of segmental elements similar to staves, of which the wall is conceived to consist, and also by the resistance of the masonry to being cracked down from the top at each end of a diametral line as the tank tended to split through the center, and each half overturn.

To accept this reasoning would require us to assume that the circumferential stretching is necessarily accompanied by the wall leaning outward about the toe of the base. In other words, that there can be no outward horizontal elastic movement unaccompanied by a bodily upward lifting of the whole wall. The fallacy of this is apparent upon the inspection of any brick wall that has bulged. In fact we might deduce from the theory of long columns that the weight of the wall could assist its own destruction.

Such an analysis was made in designing the large brick tank at Manchester already referred to. The wall was imagined as being subdivided into a number of segmental elements. The summation of the moments of stability of these was assumed as co-operating with the tensional resistance of the ring in resisting the bursting pressure. An examination of the relation of stress to strain under these two conditions of loading will show that their simultaneous existence is impossible.

Fig. 4 is a cross section of the wall of three of the tanks observed by the wr'ter. The average unit tension in a ring at

$$\text{the top 1 ft. high} = U = \frac{\left(\frac{w}{2} \times \frac{D}{2}\right)}{12T} = \frac{\frac{62.5}{2} \times \frac{185}{2}}{12 \times 48} = 5 \text{ lbs.}$$

Let,

E = modulus of elasticity of brickwork.

d_1 = increment of increase of radius, that is, the outward movement of any point in the tank circumference at the top of the wall due to ring tension.

Then,—

$$d_1 = \frac{12\pi D \times \frac{U}{E}}{2\pi} = \frac{12 \times 185 \times 5}{2E} = \frac{5,500}{E}$$

If an element of the wall measuring one foot along the circumference be now considered as a vertical cantilever, it would first deflect elastically until the adhesion of the wall to the

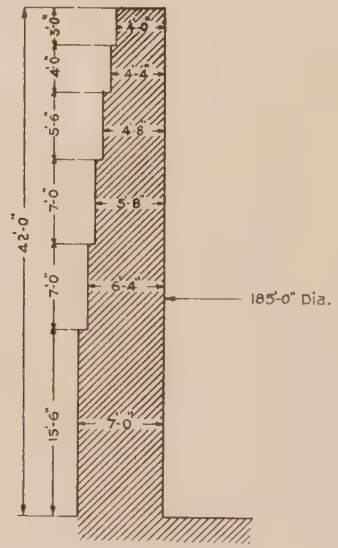


Fig. 4

base had been destroyed. This outward bending would not involve the wall being lifted bodily. Taking 208 lbs. again as the ultimate tensile resistance of the masonry, the hydrostatic pressure, F, that the wall can withstand up to the limit of its strength will now be computed.

Let,—

I = moment of inertia of cantilever

Then,—

$$F = \frac{3U\left(\frac{2I}{T}\right)}{12H} = \frac{3 \times 208 \times 14,112}{504} = 17,500 \text{lbs.}$$

The actual total pressure F_1, against the cantilever would be:

$$F_1 = \frac{H^2 w}{2} = \frac{42 \times 42 \times 62.5}{2} = 55{,}200 \text{ lbs.}$$

The deflection d_1, at the top of the cantilever due to the load F is —

$$d_1 = \frac{F(12H)^3}{10EI} = \frac{17{,}500 \times 128{,}024{,}064}{10 \times 592{,}704 \times E} = \frac{379{,}500}{E}.$$

The modulus of elasticity of brickwork E, is a very uncertain quantity. All attempts to determine it have produced values so unrelated as to be meaningless. Fortunately, however, the solution of our problem does not require us to assign to it any value. There have been derived two expressions for d_1; from the ring $d_1 = \frac{5{,}550}{E}$, from the cantilever $d_1 = \frac{379{,}500}{E}$. In both of these E relates to the *same* mass of masonry, is a common denominator, and may be eliminated. Comparing the numerators it will be found that the imaginary cantilever would deflect $\frac{379{,}500}{5{,}550} = 68.4$ times as much in resisting $\frac{17{,}500}{55{,}200} = 31.7$ per cent. of the pressure as the ring would expand in resisting all of it. From this we may deduce that the extent of this form of resistance on the part of the wall of our tank amounts to $\frac{0.317}{68.4} = 0.00464$ or less than one-half or 1 per cent. of the pressure. In the case of the Manchester holder the proportion is very much less. This cantilever theory contains a fatal defect,—it disregards the fact that the curve to which a cantilever deflects when loaded does not and cannot coincide with the curve to which a tank is distorted by internal pressure. Fig. 5 is an exaggerated representation of the two curves.

If we imagine a tank built of staves rigidly fixed at the base, the hydrostatic pressure would bend them outward opening

up the joints between. If hoops were then added to close up the joints the staves would be drawn back into the position they originally occupied. The bending in them as cantilevers would then disappear and the resistance they had offered to the water

Fig. 5

pressure would vanish with it. The hoops represent the ring tension in the masonry.

The only condition under which the cantilever action is approached is when the wall is made thick enough to reduce its deflection at the top to correspond to the expansion in diameter.

In the case of the Manchester tank it would have been over 29 ft. thick at the bottom. As tanks are built to hold water and not to practice a theory such proportions are hardly to be contemplated.

The next step in M. Arson's method is to determine the ring tension by assuming a tendency to split the wall down from the

top and overrun the halves about a diametral line as shown in Fig. 6.

Fig. 6.

M. Arson's formula, which is still in current use, for this imaginary resistance in U H^2 T which he reduced from the form $\frac{H}{2}(2\ U\ H\ T)$, in which T = thickness of wall in feet. It could be shown that the true expression for this moment of resistance, if it actually existed, would be $\frac{2\ U\ H^2\ T}{3}$, but such computation is unnecessary in view of the fact that the resistance of the earth to the tank being depressed into it in the manner indicated by Fig. 6 would be one hundred times as great. Inspection of Fig. 6 will also suggest the relation between the wall thickness at the top and bottom consequent upon M. Arson's theory.

Further discussion of M. Arson's formulæ for the resistance of the masonry seems not to be justified in view of Dr. Pole's comment in translating that it is "only an adjunct of minor importance." However, in the calculation with which the method was illustrated 42½ per cent. of the resistance was contributed by the masonry.

"The real element of resistance is the earth backing" continued Dr. Pole, referring to Arson's formula based upon an assumption that the thrust of the earth against the tank wall has the same intensity at the surface of the ground that it has at the bottom of the well. Since engineers have known otherwise for ages it is remarkable that such an analysis ever found acceptance. It is astonishing that it is still in use. Does anyone living believe that the uppermost foot of an ordinary sand

bank is capable of exerting a horizontal thrust equal to 20 times its own weight?

Arson's formula for the moment of the total earth pressure against the diametral plane $= W H (D + 2T)\frac{H}{2} = \frac{W H^2 (D + 2T)}{2}$, in which W = weight of earth per cu. ft.

Though we should go as far as to regard the earth as exert-

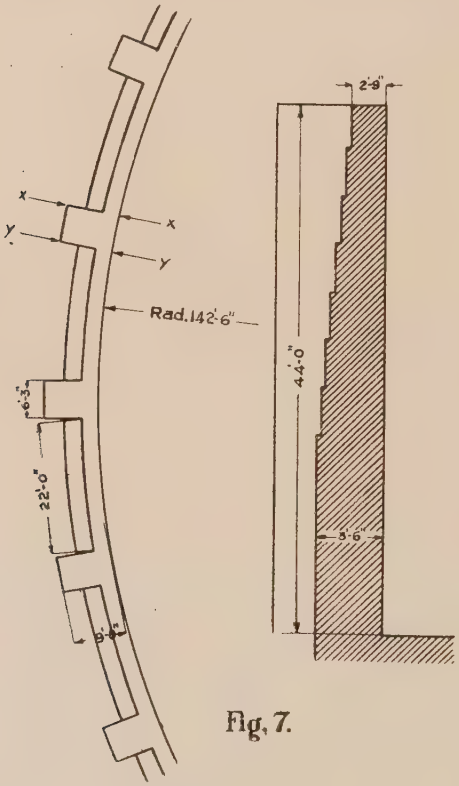


Fig. 7.

ing full fluid pressure the moment of its thrust would then be less than seven-tenths of the value deduced by Arson in his numerical example.

Fig. 7 is a vertical section and plan of several segments of

the Manchester tank taken from a paper by Mr. Frank H. Robinson, Engineering Assistant at the Manchester Gas Works. The paper was read before an English society and was printed in the "Journal of Gas Lighting" of November 30, 1909. When computed by Arson's method this tank had a factor of safety of but 2½. Mr. Robinson objected to Arson's method because it does not include the additional resistance offered by the adhesion of the base of the wall to the foundation, nor that which he supposed to be contributed by the buttresses. If that be the extent of Mr. Robinson's objections the remedy is a simple one. It is only necessary to extend Arson's analysis to include them. There is then derived a factor of safety of 2.9 instead of 2½.

Mr. Robinson's remedy for the low factor of safety was to investigate other stress conditions under which he deduced a factor of safety of 16. While doing this he overlooked the necessity of showing that the stress conditions assumed by M. Arson had neither a prior nor simultaneous existence. Until this is done the factor would remain 2.9. If while investigating the strength of a simple beam which had a factor of safety of only 2.9 against failure in bending would it add to our sense of security to discover that its resistance to shear was 16 times that imposed upon it? Right there is the defect in Mr. Robinson's analysis. He considered each panel of the wall included between two buttresses as a dam, overlooking the fundamental fact that it could not so act until it had failed in tension.

An examination of Mr. Robinson's formulæ is more amusing than profitable. They ignore not only the most elementary principles of analytical mechanics, but the laws of nature as well. These formulæ only deserve our attention because they appear to have been used in designing one of the very largest tanks in the world.

As has been stated Mr. Robinson analyzed the tank as a series of dams, each segment of the wall included between two buttresses being computed as independently stable. Taking

moments about the base, Mr. Robinson assumed the following elements of resistance:

1. Moment of resistance of earth backing.
2. Moment of stability of wall due to its own weight.
3. Moment of shearing resistance through the planes $x - x$ and $y - y$.
4. Moment of resistance of the adhesion to the foundation.

The existence of these elements of resistance in the stability of a dam is fully established, but the formulæ developed by Mr. Robinson for computing their values offend ordinary mechanical instinct. Mr. Robinson repeats Arson's error of assigning the same value to the resistance of the earth backing at all depths. As such a property does not even appertain to all kinds of rock it evidently never can be possessed by earth. The acceptance of Mr. Robinson's first equation would require us to believe that the uppermost layer of earth one inch thick, literally the surface of the ground, would resist a force of 100 pounds per lineal foot tending to shave it off. A soil possessed of such stability would be a rare and remarkable formation. It could not be excavated by the usual methods, it would necessitate the rock drill. The assistance of a brick wall in retaining the water would be unnecessary.

It is only when Mr. Robinson's equations Nos. 1 and 3 are considered in connection with one another that his method is properly appreciated. From equation No. 1 the moment of resistance of the earth pressure against the length of 22 ft. (Fig.7) is 25,560,000 ft. lbs. Hence the moment of resistance of the earth pressure against the buttress would be $\frac{6.25}{22} \times 25{,}560{,}000 = 7{,}270{,}000$ ft. lbs. The buttresses, like the wall, also derive stability from the adhesion to the foundation and from their own weight. If these elements be valued applying Mr. Robinson's methods and unit values as disclosed by his equations Nos. 2 and 4, there results 9,270,000 ft. lbs. Adding this amount to the stability contributed by the earth backing, or 7,270,000 ft. lbs. there results 16,540,000 ft. lbs. as the total moment of stability of the buttresses when computed by

Mr. Robinson's methods and applying his unit values. Now this 16,540,000 ft. lbs. would measure the entire extent to which the buttress could assist the adjacent wall, but Mr. Robinson's equation No. 3 contemplates an overturning moment over 16 times as great, or 276,000,000 ft. lbs. being resisted by that same buttress! Thus vanishes over 80 per cent. of Mr. Robinson's factor of safety of 16. If we substitute the theories and methods of modern engineering for those of Mr. Robinson, we find that after the tank had failed in tension it would have a factor of safety against overturning of about 2½.

It is interesting to observe that the investigators have confined their attention to the security of the tank against being overturned bodily. As a matter of fact that does not concern us at all and is impossible under operating conditions. The actual task is to build a water tight tank and no peril of collapse confronts us. Retaining walls of the usual proportions, resting upon earth, are generally found to lean outward in attaining their maximum stability. With other than very firm soil formations this leaning must occur if the wall is to develop its maximum resistance. Hence if a tank be assumed to consist of a series of retaining walls it is evident that the elements could lean outward and be stable but the tank would not be tight. As long as the tensional resistance in the masonry bond between the elements prevents leaning there can be no retaining wall action. When this tensional resistance has been overcome the elements will be stable but the useful career of the tank has ended.

In providing external assistance for the masonry the first resort is naturally to the surrounding earth. The particular assistance required is that which will prevent the wall from cracking. The extent to which such assistance may be derived from the backing is obviously dependent upon the character of the formation.

All geological formations lie between two extremes of condition, fluid and monolithic. The vertical pressure against an horizontal plane at a given depth below the surface of a column of fluid is equal to the weight of the fluid above that plane.

The horizontal pressure against a vertical plane of unit area at the same depth as before is likewise equal to the weight of fluid above. If the position of the vertical plane remain unchanged the pressure against it will also remain unchanged. This is the condition of *passive* pressure. If the plane recedes the fluid will follow and pressure against the plane will continue. This property of following a yielding resistance is *active* pressure. If the plane be advanced toward the fluid the pressure against it will still continue, this being the condition of *bearing* pressure.

The vertical pressure against an horizontal plane at a given depth below the top of a mass of rock is equal to the weight of the rock above, but because of the relative incompressibility and inelasticity of stone there is neither active nor passive pressure against a vertical plane. Hence, the only pressure rock can exert against a vertical plane is the bearing pressure developed by advancing the plane against the rock.

The behavior of all earth formations lies between that of fluids and that of rock. While the behavior of any particular ground cannot be foretold with much accuracy, it is somewhat consistent with the extent to which the physical condition approaches one limit or the other.

If a masonry tank be surrounded by earth in a plastic condition the internal hydrostatic pressure will be largely balanced by the active external pressure and the expansion of the tank's diameter will be reduced below that where cracking would occur.

If the tank be built in an excavation in rock the backfill may be so puddled as to transmit the internal hydrostatic pressure directly to the rock. In this case also no cracking would be apprehended.

If, however, the earth surrounding the tank be somewhat firm in character or consist of *damp* sand or an elastic clay, it will probably be capable of exerting little passive pressure and no active pressure. With such formations it will not avail to build up a thrust by compacting the backfill around the tank, as any such pressure in excess of that of which the earth be-

hind the backfill is inherently capable, is artificial and cannot continue to exist.

It is doubtless a fact that active pressure exists in some of these formations before they are disturbed, but during the work of excavating the equilibrium that had existed in the mass of earth behind the face of the excavation, is destroyed by the loss of those components contributed by the earth that has been removed. If the face of the excavation then comes to a condition of repose at a slope inclined but little from the vertical or requiring little assistance to remain so, the forces that had composed the active pressure have become adjusted to a new condition of equilibrium in which the earth does not tend to push outward and exert a thrust against the tank wall when built.

With such formations, then, the extent to which they can assist the tank is measured by the amount of horizontally applied pressure the earth is able to withstand without compressing enough to permit the tank to expand up to the cracking point. Further, if the tank surrounded by earth incapable of exerting active pressure, be other than truly cylindrical, when filled with water the wall will be drawn away from the earth at the ends of the greater diameter and thereby cracking will be induced at the ends of the lesser diameter.

It thus appears that some formations sufficiently firm to be conveniently excavated are very unsuitable for enclosing a brick tank. The best site for such a tank is doubtless one where the formation consists of either hardpan or stiff clay. The expense of excavating eliminates rock from consideration. While saturated ground is capable of greatly assisting the masonry, the excavation is expensive and the gelatinous condition of the soil makes probable the transmission of distant shocks.

It commonly occurs that brick tanks are cracked by the driving of piles nearby, but the writer has direct knowledge of two having been damaged by the use of explosives in removing an obstruction from a river two blocks away.

It is now material to discover in exact terms just what assist-

ance the tank wall shown in Fig. 4 requires of the earth. The ring tension S at a depth of 30 ft. has been computed as 14,450 lbs. If the unit stress in the brickwork be limited to 70 lbs. there will be a factor of safety *against cracking* (the only form of failure that concerns us) of about 3.

The proportion of the internal pressure thus resisted by the masonry, P_b, may be deduced from the following equation:

$$P_b = \frac{70}{\frac{S}{12T}} = \frac{840T}{S} = \frac{5,880}{14,450} = 40.7 \text{ per cent.}$$

The increment of increase in the radius of the tank, d_1, due to the circumferential stretching of the wall under a unit stress of 70 lbs. $= d_1 = \frac{12(D + T)\frac{U}{E}}{2} = \frac{12 \times 192 \times 80}{2E} = \frac{80,640}{E}$.

As has been stated investigation has failed to determine any satisfactory value for E, the modulus of elasticity of brickwork. However, it is logical to assume this modulus as not varying materially from that of the cement mortar, which modulus has been found to lie between the limits of 500,000 lbs. and 1,500,000 lbs. If we assume the average of these values and solve the equation $d_1 \quad \frac{80,640}{E}$ there results 0.0806 in. as the amount the brick wall at a depth of 30 ft. advances outward in performing its share of the work.

The outward pressure of the water on one square foot of wall at a depth of 30 ft. is 30 by 62.5 = 1,875 lbs. of which 100-40.7 or 59.3 per cent. must be resisted by the earth. Hence, we may conclude that in the absence of either active or passive pressures the tank will be secure against cracking if the earth backing be capable of developing a resistance of 0.593 by 1,875 = 1,110 lbs. per sq. foot while compressing not more than 5/64 of an inch. It is difficult to believe that such a condition has been frequently realized. The practice of reinforcing brick tanks with steel bands would indicate that the

builders of tanks have not found the earth backing a very dependable assistance.

Of the six masonry tanks approximating 185 ft. in diameter observed by the writer, three are reinforced with steel bands. These bands are all $\frac{5}{8}$ in. thick and about 5 ft. wide. In apparent compliance with Arson's theory these bands were placed just below the second offset from the top of the wall. It is a fact of much significance that, though these tanks rest on bed rock and are surrounded by very firm ground, one of them has cracked below the band.

In designing these tanks it was doubtless assumed that there would be imposed upon the band a tension approaching the maximum safe stress on the metal. As a matter of fact such a result could only be attained by cracking the masonry. Assuming the unit tension in the brickwork to be limited to 70 lbs. and the modulus of elasticity to be 1,000,000 lbs. the maximum stress possible in the steel may be deduced from the relation of the modulus of elasticity of brickwork to that of steel. The accepted value of E for steel is 29.000,000 lbs. Applying these values the unit tension developed in the steel under the conditions assumed would be $\frac{29,000,000}{1,000,000} \times 70 = 2030$ lbs. With the brick stressed up to the breaking point the unit tension in the steel would be only about 6,000 lbs.

With average unit stresses of 2,030 lbs. in the steel and 70 lbs. in the brickwork, the band will co-operate with a ring of masonry 7 ft. 1 in. high in resisting the hydrostatic pressure included between the planes coinciding with the top and bottom of the masonry ring, as shown by Fig. 8, the highly-stressed lower courses of brickwork receiving no assistance whatever from the band. The total tension in the ring and band developed by the internal pressure is 400,000 lbs. With a joint efficiency of 80 per cent. the band would be capable of resisting the entire tension while under a unit stress of only 13,500 lbs.

Though we assume any other possible stress for the masonry and any other probable elastic relation between it and the steel,

or any other vertical position for the band, similar results will follow and we shall find that whatever tensile resistance can be developed by the combination of brick and steel can be secured from the steel alone. Hence, if the brick tank here discussed were reinforced with steel bands properly propor-

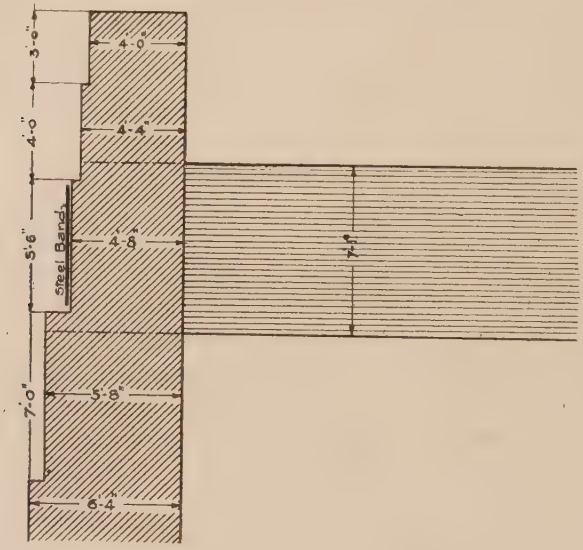


Fig. 8

tioned to keep the unit stress in the masonry below 100 lbs. it would require as much metal as a steel tank.

An established feature of modern engineering is the preference, in planning large structures, for those designs and types in which the expectation of security is based upon faith rather than hope. This may also be stated by saying that engineers avoid those designs in which the stress conditions resulting from the system of loading governing the design are either materially uncertain or not susceptible of determination. The most frequent occasion in gas engineering for applying this criterion is in the designing of holders. If the criterion should be applied even in moderation to tank design but few brick tanks would ever be built.

The writer has observed clay formations of such stability that they could not be excavated by ordinary methods. These deposits were being quarried for use in the ceramic arts. If such a formation should be found upon a site selected for a holder a strong and inexpensive tank could be constructed by merely lining a circular excavation with a thin brick wall constructed with suitable piers for supporting the guide frame. The cost of the tank would be largely defrayed by the sale of the clay. Such were the circumstances at Manchester, the clay having been made into a high class brick at the site. In view of the facts it is strange that the designers exerted themselves to devise a fictitious resistance for a wall palpably incapable of taking even a fifth part of the internal pressure.

The writer has knowledge of an engineering work where the test borings disclosed a subsoil of hardpan possessing such stability that the contractors bidding on the work were advised to estimate the excavation as being in rock. If such a formation as this should be encountered in locating a holder a tank economical and strong could be built as before, by merely lining the excavation and providing piers for supporting the guide frame.

For a tank to be so constructed it would be necessary that the formation of clay or hardpan should extend considerably beyond the tank area and evidently any disturbance of the adjacent ground would be a serious matter.

The idea seems to be prevalent that the first cost of brick tanks is in general less than that of steel tanks. It is the writer's belief that a brick tank can cost less than a steel tank only when the work begins with favorable conditions and is accompanied by them as it proceeds. If the conditions require much sheet piling and pumping the cost of a steel tank is certain to be exceeded.

While plain concrete tanks were built more than 30 years ago, reinforced concrete tanks have only appeared in the last decade. These reinforced tanks represent three different types of construction,—

1. Tanks with plain annular walls, the concrete being assumed to participate in the work of resistance.

2. Tanks with relatively thin walls, provided with outstanding piers for supporting the guide frame, the steel reinforcement being assumed to take all of the tension.

3. Tanks similar to No. 2, but with relatively thinner walls belted with hoops of reinforced concrete, the steel being assumed to take all of the tension, as before.

There are two other types for which the writer has seen designs but has no information as to their having been built. One of these types is designed with a wall similar to the familiar retaining wall with counterforts. In the other type the wall consisted of a ring of arches in a vertical plane, sprung between buttresses that were assumed to receive the outward thrust of the arches and hold them in together against the hydrostatic pressure. In neither case was the wall as designed capable of offering much resistance to tension. Hence, unless a tank built from either design rested upon solid rock or was surrounded by a very firm earth formation, it would certainly crack, for, absence of circumferential tension would require the counterforts or buttresses to be absolutely unyielding. If they were not thus rigid their outward movement would be necessarily accompanied by an increase in circumference and any such increase means tension. If the wall were surrounded by a formation of firm clay or hard pan the backing would probably be capable of withstanding the entire outward pressure with less compression than would cause the concrete to crack, but the buttresses or counterforts would be useless and contribute nothing whatever to the strength of the tank.

At the time the two 300 ft. tanks at Astoria were being designed, Mr. Bradley and Mr. Bruce made an exhaustive investigation into the question of concrete tank construction. The writer was employed upon the work as draughtsman and computer. There being practically no precedence to consider, various types of construction were devised, then analyzed and compared. The conclusion was finally reached that the concrete

tank most easily and quickly constructed, at the least cost, and in service the most reliable was the type already described as No. 1. The experience accrued during the construction of the two tanks at Astoria and the tank 189 ft. in diameter built for the Central Union Gas Co. fully justifies the conclusion that this type No. 1 is preferable to any other design of concrete tank.

The disadvantages common to both types 2 and 3 are too obvious to require much discussion. If all the tension is to be taken by the reinforcement then evidently the quantity of steel in the hoops and vertical bars will exceed that sufficient for the shell of an ordinary steel tank. To whatever extent reinforcement in place may cost less than the equivalent plate work, the economy is more than offset by the cost of the concrete. The writer believes that it has been fully demonstrated that, while the cost of any type of concrete tank must exceed the cost of an equivalent steel tank, the cost of types 2 and 3 is prohibitive.

The structural objections to types 2 and 3 are, first, the care required to properly locate the reinforcement and secure it against displacement; and, second, the great difficulty of reducing the concrete to a compact mass when its flow is obstructed by the mesh of the reinforcement. Yet whatever strength such a tank can possess is measured directly by the extent to which both of these requirements have been accomplished. The design of a tank of type No. 3 which was built in 1908 called for a circumferential reinforcement of ¾ in. bars space 2½ in. center to center and ½ in. vertical bars spaced 11½ in. apart. It is alleged that the work was executed in accordance with the plans. Hence, unless the builders resorted to a process resembling dentistry we are expected to believe that the concrete when tamped flowed through a space 1¾ in. wide by 11½ in. long and became thoroughly compacted around the bars. Fortunately this tank is surrounded by saturated ground.

Within the last few years the Board of Public Works of New South Wales built four water tanks differing in design

from type No. 2 only in the omission of piers. In 1909 one of these reservoirs totally collapsed. Though designed for a head of 40 feet it contained at the moment of failure but 32 feet of water. The engineers who investigated the collapse reported the two principal causes of failure as being; first, the concrete had not been thoroughly bedded around the bars, under which condition the tensile resistance of the steel could not be developed; and second, the filling of the tank began "only 98 days after its completion."

The engineers did not state what in their opinion should have been the age of the tank before filling but it is possibly indicated by a series of tests they had made in which specimens 98 days of age were compared with others six months old. If a concrete tank requires any such period of seasoning then the significance of that necessity is best realized by considering the fact that large holders with steel tanks can be erected complete in six months.

The analysis of stresses for a concrete tank of type No. 1 is substantially the same as that which has been applied to brick tanks. In this case also the secondary stress resulting from ellipticity may be a serious matter. With great care and much supervision during construction any considerable ellipticity may doubtless be avoided. However, the writer believes that there is sufficient probability of a tank being other than truly circular to justify an assumption that d, the increment of ellipticity has a value of ½ in. per 100 ft. of tank diameter.

In the discussion of brick tanks there was considered the restraint exerted by the foundation upon the lower part of the wall. In a concrete tank of type No 1 this restraint may be safely assumed to be effective for a distance above the tank bottom equal to 1.75 times the thickness of the wall. Hence the maximum wall thickness and the depth to plane of maximum tension are reciprocally dependent. A preliminary computation of the wall thickness may be made assuming the plane of maximum tension to be 0.8 of the depth below the top of the tank.

Evidently the consequence of this restraint upon the wall is

a shearing stress in the plane of attachment to the foundation. The responsibility of resisting this stress should be imposed upon vertical bars imbedded in the foundation and carried up 5 ft. into the wall.

The proper unit stresses for concrete holder tanks is still an open question. There has as yet been neither sufficient experience nor investigation to justify any very positive conclusions. In a tank of type No. 1 the stress in the steel is dependent upon the elastic relation of the steel to the concrete. The modulus of elasticity of concrete is an indeterminate quantity. Numberless tests have been made giving values of from 1,500,000 lbs. to 5,000,000. The building department of the New York City assumes the ratio of the modulus of elasticity of concrete to that of steel as being 12 but 15 is the ratio most frequently assumed by engineers when not restricted by ordinances.

The unit stress that may be safely assumed for the concrete is somewhat dependent upon the character of the surrounding earth. For instance if the tank be located in saturated ground we may with considerable accuracy compute the minimum value of the active pressure that will act inward against the wall. Hence, if the unit tension in the concrete were assumed at 90 lbs. we might expect with reasonable certainty that that stress would never be exceeded. If, however, the tank be surrounded by damp sand it would be hazardous to assume such a stress as 90 lbs. unless the sand be regarded as incapable of either active or passive pressure.

With the earth pressure assumed in designing the Astoria tanks the maximum tension in the concrete would be 83 lbs. but from the character of the formation as disclosed by the excavation the writer would conclude that it does not exceed 25 lbs.

In the case of tanks of type No. 1 under 175 ft. in diameter the wall thickness will generally be determined by the width at the top necessary to accommodate the base of the guide frame standards. This thickness if continued down to the bottom may sometimes be in excess of that necessary to re-

sist the maximum tension. Hence it may be suggested as an economy that the wall thickness be reduced and piers added to the outside of the wall for supporting the guide frame. It can be shown, however, that such a modification may result in increasing the cost of the work. Tanks of type No. 1 are usually constructed by moulding the concrete between two concentric rings each consisting of segmental forms about 6 ft. high. As the work proceeds these forms are slid upward in vertical guides. It is apparent that outstanding piers will interfere seriously with the continuity and facility of this process and offset the economy in concrete. Also, from a frequent experience with buttressed retaining walls, we may conclude that the corners formed between the wall and piers favor the development of cracks. The design of type No. 1 is based upon a theory supported by experience that it is cheaper to put in more concrete and avoid complicated form work and tangles of reinforcement.

In proportioning the reinforcement for type No. 1 it is not advisable to exceed 2½ per cent. in any unit height of the vertical section. If this amount be materially exceeded the bars will be spaced too closely to permit the best results in placing the concrete, and the additional steel not being economically employed will increase the cost very perceptibly.

The concrete in the upper half of the wall will rarely require the assistance of reinforcement in resisting the ring tension, but one-half of one per cent. of steel in that part of the wall will do much to prevent shrinkage or temperature cracks.

Except in the unusual case of a tank having earth formations radically different in behavior acting against opposite arcs of its circumference, any computation of the tank's resistance to externally applied pressure is unnecessary. Though we should assume an external fluid pressure from a saturated earth weighing 110 lbs. per cubic ft., the maximum unit compression in the concrete would not exceed 600 lbs.

Only very small tanks of types No. 2 and 3 have as yet been built. These tanks have most of their depth above the surface of the ground. As has been stated, these types of

construction are expensive hence for economy it has been the practice to employ the steel at stresses as high as 25,000 lbs. When the stress in the steel reaches 5,000 lbs. every vestige of the tensile resistance of the concrete has been destroyed. It is not this fact in itself that concerns us, however, but the attendant condition of the concrete. It has been established by experiment that when concrete is thus strained there is developed a countless number of cracks which, though invisible, are not less real. In this condition the concrete is not impervious to water and it has been found that a mere seepage through the wall will eventually become a flow. Furthermore the alternate freezing and thawing of the water in the cracks results in a gradual splitting of the concrete.

In 1907 the Board of Water Supply of New York City made extensive tests with a reinforced concrete cylinder 11 ft. in diameter and 210 ft. long. The walls of the cylinder were 8 in. thick and contained 5 per cent. of reinforcement. The high grade of the concrete was shown by the average ultimate tensile resistance of 330 lbs. developed by specimens seven months old, that being the age of the cylinder when first subjected to pressure. Under a head of 28 ft. the leakage from the cylinder was over 900 gallons per hour. After the interior surface of the concrete had been grouted twice and coated with cement mortar the leakage was reduced to about 45 gals. per hour under a head of 34 ft. Under this last condition the steel was under a unit tension of only 1,100 lbs. The writer does not know what conclusions were formed from these tests but assumes them to be reflected in the practice of the Board of Water Supply of limiting the unit stress in the reinforcement of water-retaining structures to 8,000 lbs.

The existing holder tanks and reservoirs conforming substantially to types No. 2 and 3 in design have maximum wall thicknesses of 18 in. for No. 2 and 10 in. for No. 3. A considerable increase in this wall thickness would doubtless prevent seepage but this would lead us in the direction of type No. 1.

Tanks of these types cannot be made tight by waterproofing for the reason that such coatings to be effective must be applied to the inner surface while the wall is under tension. If applied to the outside it will be useless. Such tanks have been made tight by charging the water in them with cement, but there is no certainty of this process being successful unless all of the water in the tank be converted into grout.

In some very important particulars concrete tanks of any type are less desirable than those of brick. For, while brickwork has been discussed as an uncertain material for resisting tension, concrete is even less dependable when thus employed. The structural principles of concrete and brickmasonry are essentially the same, but the latter represents the systematic assemblage of the elements. This process permits complete inspection as the work proceeds. Brickmasonry does not require the exercise of any peculiar skill nor that momentary vigilance so necessary in concrete work, hence good results are more easily secured. Concrete work may turn out unintentionally bad but it will never be accidently good.

Brick-work is not liable to the serious cracks that develop so frequently in concrete as a result of the inherent shrinkage stresses. Furthermore it is a simple matter to repair the wall of a brick tank and obtain the original strength. With concrete repairing is difficult and the results doubtful.

In the event of a destructive storm during the building of a masonry tank any damage sustained by brickwork would be palpable while impaired concrete might escape observation.

When a more extended use of concrete began ten years ago it was believed that structures built of sand, cement and broken stone were practically immortal. They were said to become a part of geology. Doubtless the experience accrued in the last ten years has convinced engineers that concrete structures are not more enduring than the other works of man.

In no other field of human industry have science and skill been so extensively and successfully applied as in the production of structural steel. Manufactured from the most im-

portant of the metallic elements the original granular formation is readily transformed into an elastic fibrous structure. Structural steel is manufactured in several grades, each differing from the other in physical properties. The desired properties of tenacity and ductility are developed by mechanical processes and by varying the proportion of certain chemical constituents. The custom of specifying these chemical properties in hundredths per cent. indicates the perfection the art has reached. The certainty and uniformity with which any specified grade or quality of steel may be produced is in marked contrast to the random results from the manufacture of other structural materials.

An ideal stress condition may be described as that condition which is developed in a material of definite and uniform elastic properties by a completely known force. Such ideal conditions are never more nearly attained in practice than when steel is employed to resist fluid pressure.

The usual specification for steel plates for holder tanks permits a variation of 10,000 lbs. in the ultimate tensile strength and requires the elastic limit to be not less than one-half the ultimate. The ultimate strength of tank plates is generally assumed at 60,000 lbs. and records available to the writer of tests made upon thousands of tons of such material show rare instances where the variation from that figure was 5 per cent. Hence it may be said that while steel tanks are designed upon an average resistance which varies 10 per cent. masonry tanks are proportioned upon the basis of the poorest material that human frailty may permit to enter the structure. Someone has defined a factor of safety as "the factor of ignorance." In the case of masonry tanks, it would be very properly defined as "the factor of our helplessness," for we are helpless to either influence or control the tensile resistance of masonry within 100 per cent.

The shell of a steel tank, like the wall of a masonry tank, receives material assistance from the bottom though this fact is not usually considered in designing. Fig. 9 is an exag-

gerated representation of the elastic deformation of a steel tank. The thickness of the plates at the top of the shell is governed by practical considerations and is always much more than the stress conditions would require. This excess of metal, assisted by the circular girder, reduces the diametral expansion at the top of the tank to a very small amount. At

Fig. 9.

the bottom of the shell the diametral expansion is reduced to an almost imperceptible increment by the restraint of the bottom. The amount of this restraint is best realized by conceiving a large tank to be cut into two parts by a vertical diametral plant. Then if the coefficient of the static friction

between the bottom and the foundation equals 0.3, the friction would exceed the whole bursting pressure tending to spread the two halves of the tank apart. Or, ignoring the friction and assuming a joint efficiency of 50 per cent. for the bottom seams, the bottom plates would be capable of resisting the entire hydrostatic pressure acting on the lowest ten feet of the tank shell. The flexibility of the plates will, however, prevent the restraint from being materially effective above the first rim.

The assistance contributed by the bottom of the tank to the lowest rim of side plates is much more effective when the curb angle is placed on the outside of the tank. If, with such a condition, the thickness of the lowest rim be proportioned to a stress computed from the condition of an unrestrained ring under hydrostatic pressure, an analysis of the elastic behavior of the rim in connection with the curb angle and tank bottom will show that the actual unit stress at the bottom of the rim does not exceed 10 per cent of that assumed in designing. If the rim approximates 4 ft. in height the unit stress at its upper edge will not exceed 90 per cent of that assumed in the design. From this it will be seen that, having determined the unit stress permissible in the plates, that stress will be more nearly approached if the thickness of each rim proportioned to the tension at the center of the rim. The frequent practice of proportioning the plate thickness to the tension at the bottom of the rim is inaccurate and results in an unnecessary amount of metal. It is certainly neither rational nor intelligent designing to accept one unit stress as permissible and then assume fictitious conditions that produce some other stress.

Though holder tanks of steel have been in use for more than twenty years there is still a lingering distrust of their security. Those that entertain this distrust seek to justify it not by the failures but by the lack of them. The idea seems to be that a failure is more or less equivalent to a test to destruction and hence, if more steel holder tanks had collapsed, their behavior under pressure would be better understood. There is doubtless

some logic in this argument, but from the fact that of all the many large steel holder tanks that have been constructed in the last twenty odd years there is a record of but one failure, we may safely conclude that a more exact knowledge of the true stresses in the tank shell would result in less metal and rivets than are employed in the practice of the present time.

In connection with the recent design and construction of two large steel holder tanks, tests of prepared rivetted specimen joints were made by the builder.

The tests indicate:

1st. That the strength of a double butt riveted joint is not less than the total strength of the elements of which it is composed, taken separately.

2d. That the ultimate resistance of a tank plate is less than that stress which would be necessary to break down the friction in the joint.

3d. That the frictional grip in such joint is so great that within the limits of working stresses there is neither shear in the rivets nor bearing stress against the shank.

Fig. 10 is a partial cross-section of the spherical type of tank of which several have recently been built in Europe. With this design the thickness of the plating is independent of the diameter. The profile of the tank on a radial line is an equilibrium curve known as the hydrostatic chord. The tension at any point in the walls of any vessel having a curved perimeter under fluid pressure in equilibrium is equal to the product of the unit pressure and the radius of curvature. Hence, as the internal pressure is met by the tensional resistance in a meridional plane without developing any serious circumferential tension, it is evident that this design permits the plating to be very thin. To make the nearest approach to ideal stress conditions requires that the shell of this tank shall be uniform, elastic and unrestrained.

The advocates of this new type of tank are asserting its alleged advantages with an immoderation that may remind us of the enthusiasm with which the suspension bunker was first

introduced. The suspension bunker has been in the field now for some twenty years. It has its merits and is extensively used, but it has absolutely failed to eliminate those standard types of bin construction that were in use before it appeared. If a spherical tank is to eliminate the usual cylindrical form,

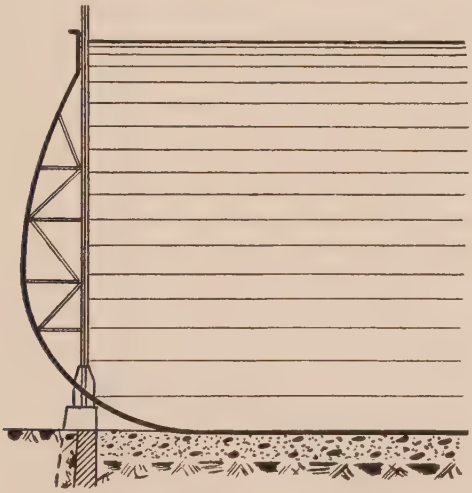


Fig. 10.

the design must be demonstrated as possessing more considerable advantages than have yet been shown.

In the Journal of Gas Lighting of July 5, 1910, there appears a discussion of steel holder tanks by M. Edouard Bonnet. The paper is an argument for the new type of tank and consists in comparing the alleged disadvantages of the cylindrical construction with the supposed advantages of the spherical tank. Nothing is stated by the author about the disadvantages of the spherical tank.

M. Bonnet begins his condemnation of cylindrical tanks by acknowledging the bottom plates as being necessary to retain the water. In the next sentence he states that the bottom con-

tains an "amount of metal————which has no really useful place in the construction." If that statement be true it follows that the shell of the tank is also unnecessary, as likewise, its only purpose is to retain the water.

The thickness and behavior of the tank shell is next discussed by M. Bonnet. He takes a serious view of the difficulty and labor involved in assembling the heavy plates required for the cylindrical tank. The fact that the entire first rim of the 10,000,000 Holder at Newtown was assembled and riveted in eleven working days without extraordinary effort would suggest that M. Bonnet is not without prejudice. He then states that "while the interior pressure increases the diameter of the tank, the bottom of the lower ring of plates strengthened by the angle iron and held by the bottom plates, cannot take part in the general tension of the circumference, and causes partial strains which are dangerous and lead to bursts." Can M. Bonnet explain why the condition of the lower ring of plates is dangerous when it is "strengthened by the angle iron and held by the bottom plates"? Also, why are "partial strains" more serious than the entire strain?

His next statement is that the circular girder at the top of the tank does nothing. "Its only effect is to insure the circular form of the tank and it adds nothing to its strength." From this we may assume that a tank is not strengthened by insuring its circular form. It would also greatly enlarge our knowledge if those "certain parts" of a cylindrical tank in which the metal "exerts itself badly" were definitely stated.

A fair comparison of the two types of tank will show that the reduction in plate thickness which the spherical tank permits is its sole advantage. The spherical tank, as constructed makes no closer approach to the ideal stress conditions upon which the design is based than does the cylindrical tank. A mechanical analysis of the hydrostatic chord assumes the element to be unrestrained at any point between the termini. The sperical tank is not and cannot be so constructed. The tank described by M. Bonnet has a number of radial vertical

girders attached to the outer shell, there being apparently one girder under each guide frame standard and two in the space between. The bases of these girders are supported by pedestals outside of the shell resting upon the annular foundation. Each vertical element of the tank coinciding with one of these girders is subjected to a considerable restraint, while an element midway between is free except to that extent to which the rigidity of the plating may transmit the restraint of the girders around the circumference. Will some advocate of the spherical tank enlighten us as to what extent the ideal stress conditions are disturbed by this restraint, or as to the nature and amount of the stress thus induced? Further, M. Bonnet referring to the stress induced in a cylindrical tank by the guide frame states "such a tank———has thus added to it considerable strains varying in position and intensity which it is almost impossible to ascertain." In view of this statement it is somewhat remarkable that he omits any discussion of the corresponding stresses in a spherical tank.

M. Bonnet discusses tank foundations in utter disregard of the fact that the shell of a cylindrical tank represents a circular girder of great depth and stiffness. The writer has seen a cylindrical tank of large size, the foundation of which had been undermined by adjacent excavation without serious results. A spherical tank is a relatively flabby construction and is absolutely dependent for its security upon an unyielding foundation. If one arc of the annular foundation were to subside, is the structure of the spherical tank adapted to bridging across the depression? An unequal settlement of cylindrical tanks has occurred with sufficient frequency to demonstrate the inherent strength of its form as a circular girder. The author also states, referring to spherical tanks, "even the bottom only supports the weight of water." What else does he assume the bottom of a cylindrical tank to be carrying? He then says that "calculation has shown that an important depression in this part of the foundations would require only a slight increase in the work done by the plates."

We might observe in this connection that calculation has shown that an important depression in this part of the foundation under a cylindrical tank would reduce the work done by the plates in the shell, and actual experience has demonstrated that no harm results. An unmistakable advantage of the cylindrical tank is its security when supported upon an annular foundation. The Consolidated Gas Company of New York has a holder, the steel tank of which is 193 ft. 2 in. in diameter and 41 ft. 9 in. deep, the tank being supported by an annular pile foundation. The site was originally under water and was filled in upon black river mud of a considerable depth. The foundation has now carried the load for 22 years without settlement.

All innovations should receive a fair hearing and full consideration, but on the other hand, the claims of merit should be candidly and honestly presented. The writer does not believe that much can be accomplished for an alleged improvement by subjecting existing practice to unfair and truthless criticism.

Though steel tanks have been built in large numbers, there seems to have been little investigation into the behavior of the inner surface of the plating where exposed to the action of the water in the tank. Hence the question has been frequently raised as to what the effect of the water upon the inner surface of the shell might be. During the present year the writer had opportunity to examine a large steel tank which was built at a time when the manufacture of open hearth steel plates was in its infancy. The material in this tank has been shown to be of very inferior quality, but notwithstanding this fact, after nearly twenty years exposure to the action of the water, the interior surface of the shell could be described as being in perfect condition.

The Consolidated Gas Company has usually placed its large steel tanks with some part of their depth below the level of the surrounding ground. It has been their practice to protect the shell below the ground level with a thin concrete wall. A

recent examination of the tanks so located showed that the concrete remained in absolute contact with the surface of the plates and that no corrosion had occurred.

Among the distinct advantages of steel tanks, when compared with those of masonry, are:

1st. Less Cost.

2d. Shorter period required for construction.

3d. The ease with which the quality of the work may be controlled during construction.

4th. The high state of development in fabrication and erection.

5th. Greater reliability under stress.

6th. Accessibility for inspection.

7th. Tank may be placed at any elevation with relation to the ground line that may be desired.

8th. No liability to damage by storm during construction.

9th. No internal stresses from shrinkage or temperature that are serious.

10th. Possibility of rectifying an unequal settlement.

11th. No liability to cracking from undertermined causes.

12th. The ease of making repairs and obtaining the original strength.

The writer may be charged with entertaining a strong prejudice against masonry tanks. He will admit that he is opposed to any type of tank, 25 to 40 per cent. of the cost of which may go into digging a hole in the ground instead of putting quality into the structure.

THE PRESIDENT: I have a written discussion of this paper by Mr. H. A. Carpenter, Mr. Brundage will kindly read it.

Mr. Alrich's paper gives evidence of very intimate knowledge and consistent reasoning in regard to brick and concrete holder tanks. His work on this subject should be of great value to Gas Engineers, giving them in a few pages a comprehensive statement and correct deductions of the elements and facts involved.

Generally speaking, masonry construction for holder tanks receives little consideration to-day. Steel is preferred on account of smaller cost and less time required to construct a satisfactory tank. At the same time, it is not well to assume that the steel tank is necessarily a "cure-all" for the various deficiencies of the masonry tank, and the Gas Engineers, who have this problem to meet, may well give most minute study and attention to the elements which go to make up a steel tank which is safe beyond question.

The Author's reference to failures of steel tanks is inclined to belittle the risk involved. He makes no reference to the enormous probable damage in the event of a failure of a steel tank, especially when it is located in a city block, surrounded by buildings and possibly in a thickly populated section. The very fact that even one such failure should have occurred would be sufficient reason that all Engineers who are called upon to provide such structures should analyze most carefully the reasons tending to failure and guard against them with such surety that there would be no possibility under ordinary circumstances for the occurrence of such a catastrophe.

The mere fact that steel tanks have been built and are standing to-day, in which practices have obtained that may be reasoned as causes for such failures, is no proof that such practices will in no case result in the destruction of a steel tank, or that eventually the particular tank in question will not fail. The difference in cost between a steel holder tank, in which the best of material, proper treatment of same, careful workmanship throughout has obtained, may be very much greater than a similar tank in which such items have received less consideration, but the risk involved is such that sufficient expenditure to guard against every probable known reason of failure in such a structure should be met.

Page 35, quotation. "The assistance contributed by the bottom of the tank to the lowest rim of side plates is much more effective when the curb angle is placed on the outside of the tank."

The connection between the side plates of tank and tank

bottom must be of sufficient strength to transmit the load involved from one to the other. This being the case it matters not whether curb angle is on the inside or the outside of the bottom course—in either case the riveted connections as well as the bottom curb angle itself, must be of sufficient strength to transmit the load.

Page 35, quotation. "From this it will be seen that for determining the unit stress permissible in the plates that stress will be more nearly approached if the thickness of each rim be proportioned to the tension at centre of rim. The frequent practice of proportioning the plate thickness to the tension at the bottom of the rim is inaccurate and results in an unnecessary amount of metal."

The strain in each element of the tank shell is, of course, dependent on the head of water, and if the problem were theoretically met, taper plates would be required. It is of little importance whether the top, centre or bottom of each ring of plates is assumed as the head in figuring the strain in tension so long as both the point at which the head has been assumed and the tension resulting at that point are stated, in which case one can intelligently consider the factor of safety involved.

Mr. Howard Bruce: Mr. Alrich refers to the Central Union tank and the Astoria tank. In the case of the Central Union tank the water stood on the outside within eight feet of what it did on the inside. In the case of the Astoria tank it stood within fifteen feet on the outside of what it did on the inside, and consequently those two tanks, I think, are simply guides for the holder; they are not tanks. He also says, "Certain tests indicate that the strength of the double bowed joint is not less than the total strength of the elements of which it is composed." I wish to say those tests were five in number and that they were very incomplete; they were not made to draw any such general conclusions from, and I think Mr. Alrich's conclusions are based on insufficient information. He goes into the subject of spherical type of tank and dismisses it with a comparison with the suspension bunker. The

spherical type tank is theoretically sound. It is based on the assumption that you can transfer one-third of the strains to the top curve and two-thirds to the bottom. Mr. Alrich dismisses it, but he does not do it on commercial grounds. The only grounds on which you can consider this tank is that when you go beyond the limit of commercial steel, or nickel steel, you can put enough steel in the top curve to carry that one-third, and you can place in the foundation enough to carry the other two-thirds. In his final conclusions he says something that is very gratifying to the manufacturer of steel tanks, but at the same time I disagree with him. I think that each particular case is dependent upon the local conditions: that there are certain conditions under which a concrete or masonry tank is more economical and more desirable from every standpoint, and I do not believe that you can draw any general conclusions. In some cases you may put 25 to 40 per cent. of the cost into the foundations, and at the same time have your completed construction at a less cost than if you had constructed the steel tank.

Capt. W. E. McKay:—The Boston Consolidated Gas Company has built, in the past few years one holder tank 190 ft. 3 in. diam. by 42 ft. deep, and three tanks 96 ft. 6 in. diam. by 28 ft. deep. These tanks were all built of mass concrete, though all of them were reinforced with 2½ in. × ¾ in. round edge flat bars, bent to the radius of the tank and overlapping ends secured by bolting. These bars were to take care of shrinkage or temperature cracks.

The walls of the 96 ft. 6 in. diam. tanks were 36 in. thick at the bottom and diminished to 24 in. thick at the top in three steps at equal heights up the wall. The forms were made to fit the lower section, and were 7 ft. 8 in. high. These forms were used for the rest of the wall, lapping the inside form 8 in., and setting up the outside form on the concrete already placed. The piers were carried up of the same size from the bottom to the top and offered no difficulty in setting up the forms, and did not increase the cost appreciably. Care was taken to make

vertical joints stepped with V shaped grooves in same, and all longitudinal joints were well washed and swept with a wire broom, the forms well wet and the surface of the concrete covered with a mortar of one part of cement to one of sand, before starting to concrete the next section.

Similar methods were employed on the 190 ft. 3 in. diam. tank, the wall of which was 68 in. thick at the bottom and diminished to 30 in. at the top.

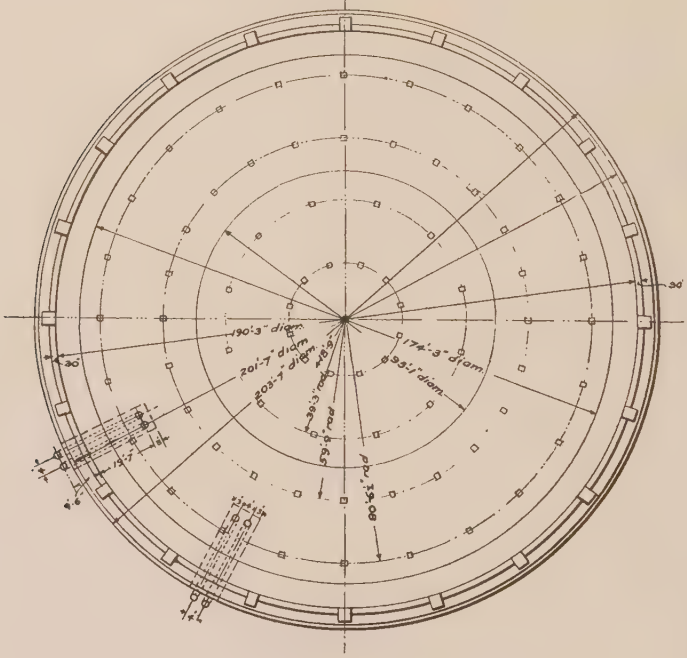
In none of these tanks was any provision made to resist shearing at the bottom of the wall by placing vertical reinforcing rods.

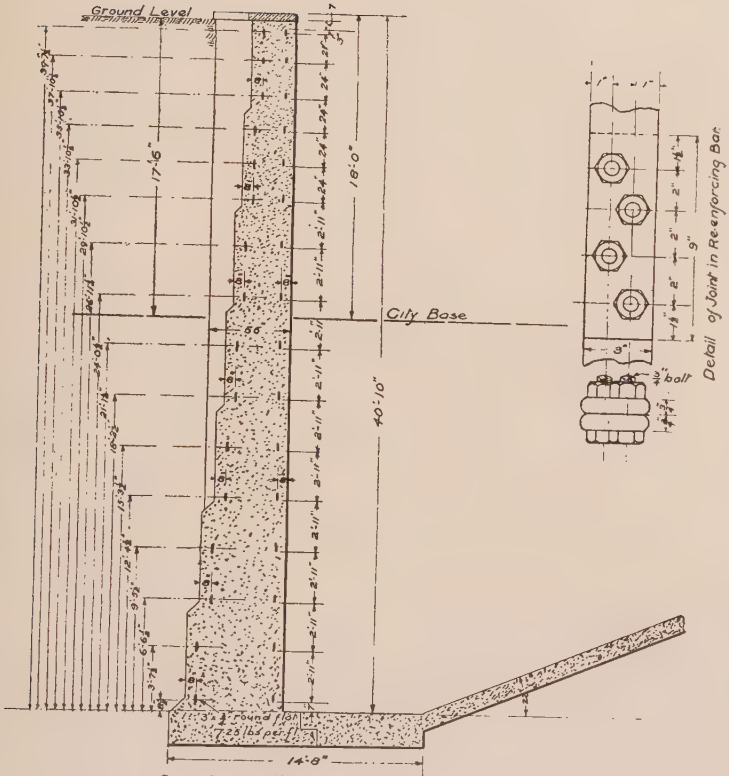
The three smaller tanks had flat bottoms 12 in. thick and were reinforced with expanded metal. The large tank had a bottom 12 in. thick with no reinforcement. Two of the smaller tanks were built in sand, and one in blue clay. The large tank was built in hard yellow clay. All the tanks were coated inside with hot tar. All the tanks are absolutely tight and are giving perfect satisfaction.

We found that it was necessary to leave vent pipes in the bottom of the tanks to relieve any pressure in event of the stoppage of the pumps. Before filling the tanks these pipes were of course closed securely.

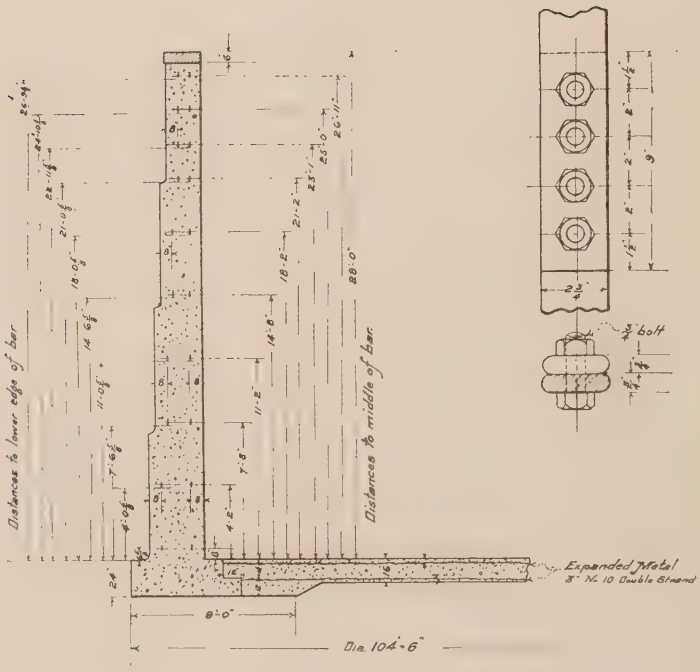
I have some drawings that illustrate the construction which I will submit for the proceedings.

Plan and Sectional Elevation showing Location of Pipe Connections and Concrete Piers for Permanent Frame.





Section of Wall and Bottom and Re-enforcement of Concrete.



Re-enforcement of Tank Wall and Bottom.

Mr. Alrich: In regard to Mr. Bruce's remarks, I referred to that point somewhere in the paper, stating that from the actual conditions that exist in the ground surrounding the Astoria tank, it was probable that the actual tension in the wall of the tank was very slight.

The President: It is proper to give Mr. Alrich a vote of thanks for the paper he has written. It represents a great deal of work, and care in its preparation.

A vote of thanks to Mr. Alrich for his paper was carried.

THE PRESIDENT: The next paper is on

CONSTRUCTION OF A REINFORCED CONCRETE TANK FOR A GAS HOLDER.

BY MR. V. L. ELBERT.

MR. ELBERT: (Reads paper)

CONSTRUCTION OF A REINFORCED CONCRETE TANK FOR A GAS HOLDER.

Some four years ago we installed a reinforced concrete tank to contain a four lift Gas Holder.

This tank differed from the ordinary pit tank to the extent that only an annular ring was excavated and the center or mound left in tank.

I believe I am not mistaken in stating it is the only one of its kind in this country, and therefore believe a paper on the above subject will be of interest to the members of this Institute and hope of some benefit to anyone having a similar proposition in mind.

The dimensions of this tank are as follows: (See drawing No. 2).

96 ft. 6 in. diameter and 31 ft. 2 in. deep inside.

99 ft. 2 in. diameter outside, that is the circumference walls were 16 in. thick.

The number of column bases were 10, each base 3 ft. square and they extended out from outside circumference wall 1 ft. 8 in.

The walk around at top of tank was 2 ft. 2 in. wide and 6 in. thick. The annular ring when finished was 9 ft. wide inside. The mound was 78 ft. 6 in. in diameter and 20 ft. high or 11 ft. 2 in. lower than the top of outer circumference wall.

We decided on this style of a tank instead of a steel tank as the foundation for a steel tank and protection for same would have cost quite as much as a complete concrete tank, on the site we had to place it.

Site.

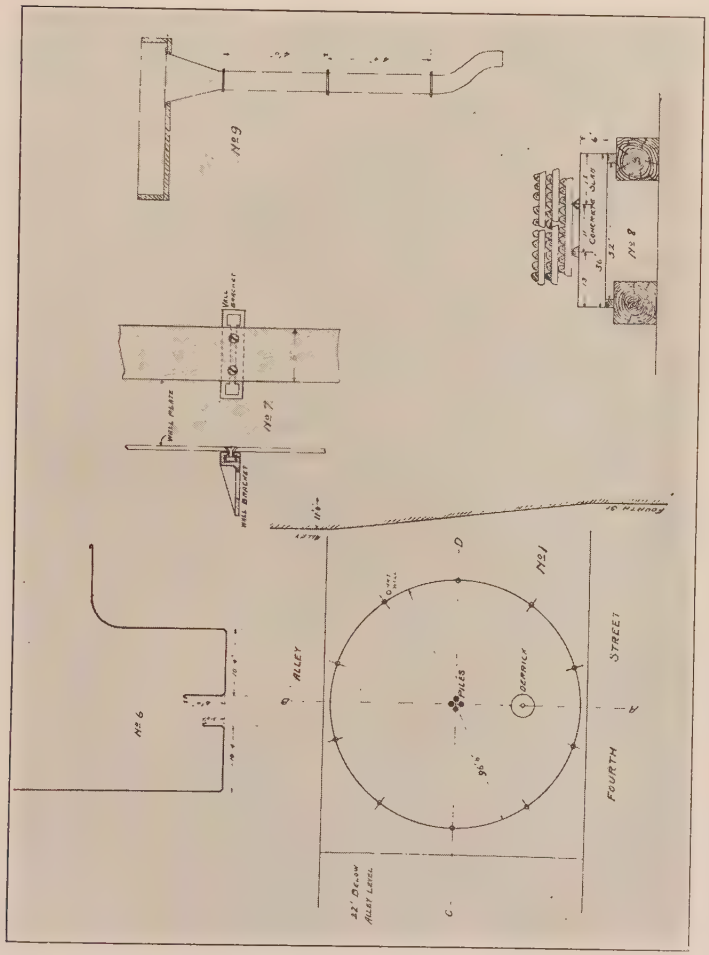
Photo. No. 1. *Drawing No. 1.*

The site we had was the only one adjacent to our gas plant

Photo No. 1.

Shows site for tank. Pile driver ready to start work. Tank center about where pile driver engine is shown. Hoisting engine for derrick to left is on 11th street. Building to right is Purifying House. Buildings with staging is meter building just completed. Building on the left adjoining this site not Gas Company's.

was sloping from the alley to 4th Street 11 ft. From east to west we were limited for room on account of an artesian well



Drawings Nos. 1, 6, 7, 8 and 9.

on the east that we had use for, on the west a deep hole some 22 ft. below alley level or top of tank.

This site was originally an old marsh and had been used near west line for a city dump and water was encountered

16 ft. below the top of alley, which had to be kept out during the construction of the tank and holder.

Laying Out.

Drawing No. 1.

After clearing the property we at once laid out the center of tank and with a transit, each of the center lines for the ten columns, being particular to have two columns straddle the center line "A" "B" on north and south property line for our property from north to south was only 101 ft. 4 in. and the extreme diameter of the walk around on top of tank was 100 ft. 10 in., leaving 3 in. to spare on each side of the walk around to the property line.

The center was a nail point in a wooden block in the end of a piece of gas pipe driven into the ground about flush with the same and an excavation around same filled with concrete, this held the pipe absolutely steady.

Sump Hole.

Photo. No. 2. *Drawing No. 5.*

A sump hole was then started 8 ft. by 16 ft. on the south-east corner about 6 ft. from the outer circumference of tank, for the purpose of draining the water into as the excavation progressed, and for one 24 in. outlet pipe. This hole was heavily timbered with 2 in. by 8 in. by 12 ft. sheeting sharpened chisel shape on the lower end with 6 in. by 8 in. for stringers and braces on upper 12 ft. and 8 in. by 8 in. timber on lower 12 ft., the lower 12 ft. was driven inside of upper section.

Across the top of this hole and a few feet above a beam was placed and from this a pulsometer hung from a chain block which was lowered as the hole was sunk to remove the water. Steam for the same was furnished from the Gas Works some 300 ft. distant. This hole was sunk some 3 ft. lower than the bottom of the drip pot or 30 ft. lower than 4th Street. From the side and bottom of this hole a 12 in. sewer tile was laid to the center of the annular ring and connected to the drain to be described later.

When tank was completed a shaft of concrete 3 ft. in diameter inside was constructed in sump hole from the bottom to the ground level. Near the bottom the 12 in. tile drain entered

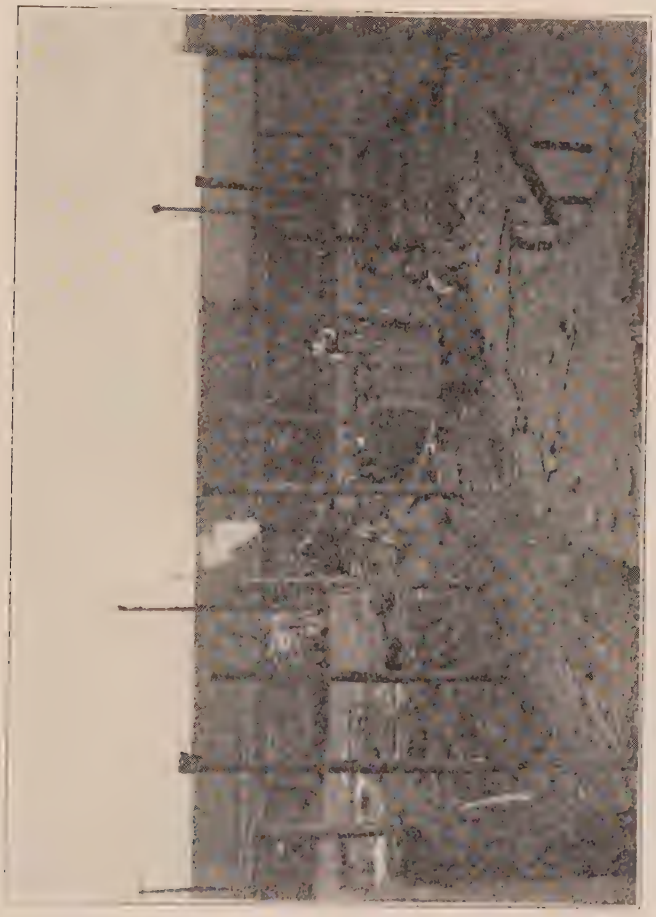


Photo No. 2.

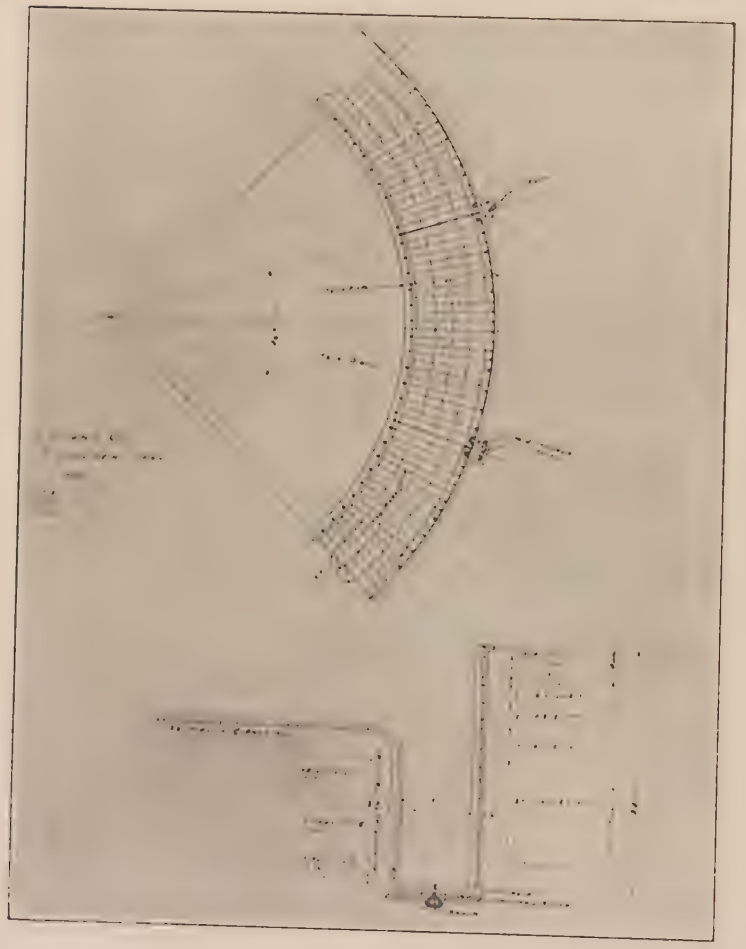
Shows sump hole started on outside of outer piling and some of the outer piling in the east and south driven. Excavation started.

this shaft. The top of shaft has a plank cover bolted on, which proves convenient to observe height of water at any time on outside of tank.

TRAM.

Photo. No. 3. *Drawing No. 3.*

Four piles are driven around center nail point, two on line



Drawing No. 2.

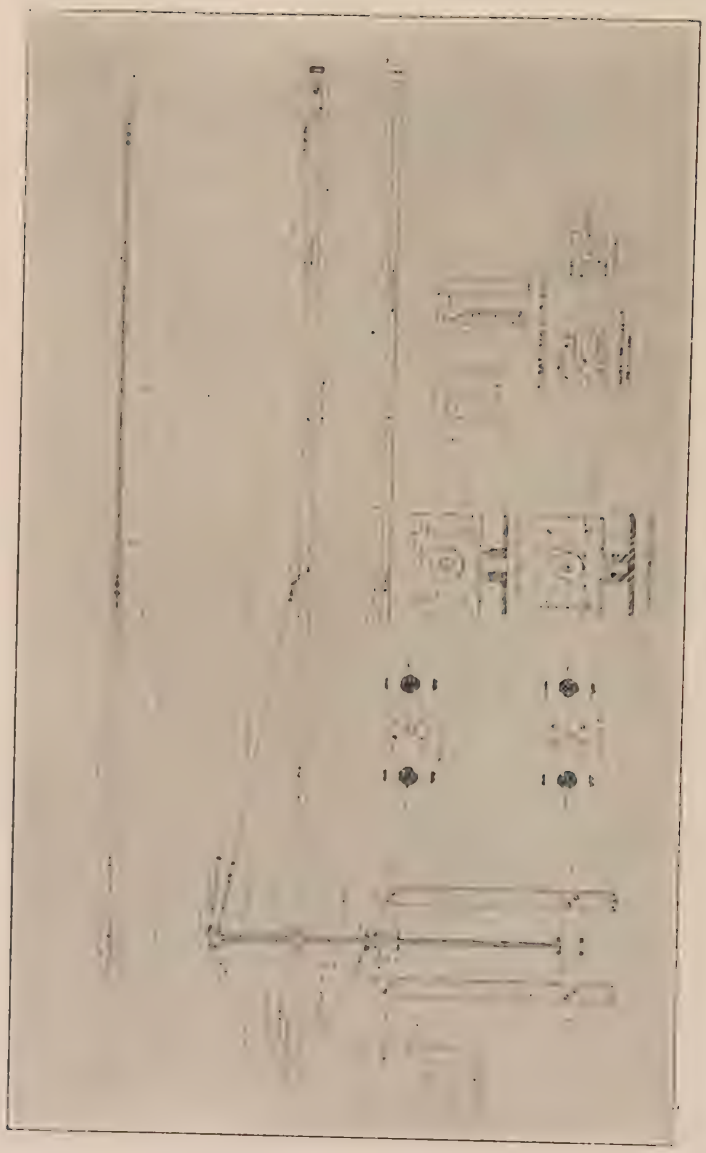
with derrick "A" "B" and two perpendicular on line "C" "D" all being thoroughly braced at the bottom. The two on

line "C" "D" being cut off four ft. above the mound, the two on line "A" "B" were left some 12 ft. above the mound. The

Photo No. 3.

Shows piling all driven for both inner and outer ring, also four piling in center, two long and two short for carrying tram. The sheeting for top section started. The derrick on line "A" "B" to the south of tank center.

tram arm was 5 ft. above the top of the finished tank. The details for tram show tram proper only 35 ft. long from



Drawing No 3.

center of shaft to outer end, an extension piece of wood ¾in. by 3½ in. by 22 ft. was made to slide through the end marked "X" as an extension piece, with holes through the side at stated intervals and a ½ in. pin put through the holes at "J" near end of tram and 7 ft. towards center to hold extension piece in place when extended beyond the end of tram.

The main part of tram was made only 35 ft. in order to clear the inside piling as shown on drawing No. 4 which were some 12 ft. above the mound.

Derrick.

Photo. No. 3.

The derrick was the ordinary guyed kind with a mast high enough for the guy wires to clear tank sides to a height that the derrick boom could swing in most any position without interference and with the exception on a line with the shaft of the tram was available at any point of the circumference of tank, the boom being some 90 ft. long.

Piling.

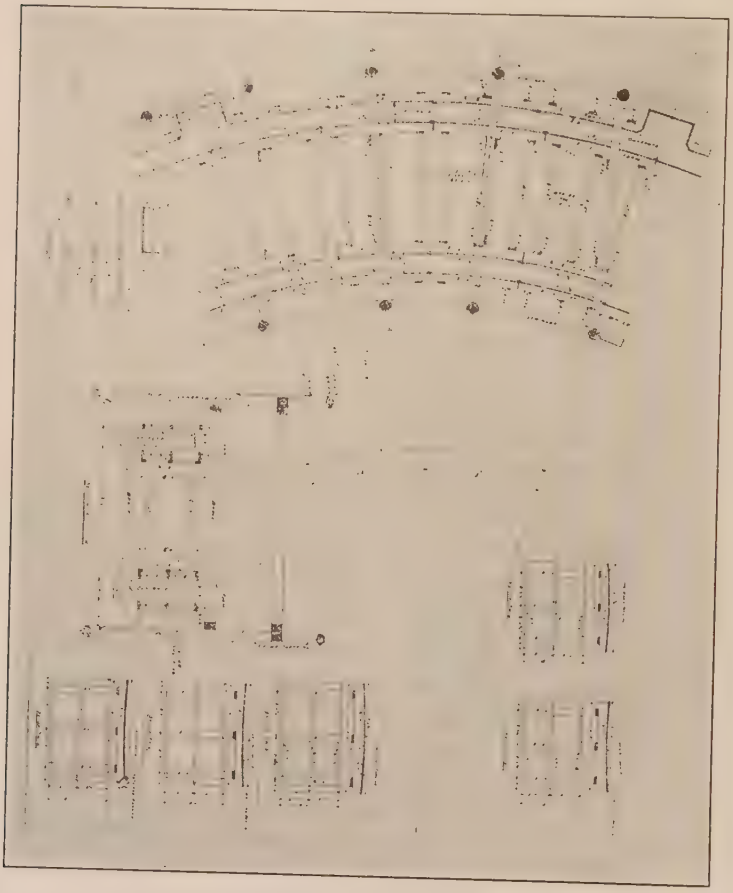
Photo. No. 3. *Drawing No 4.*

In order to hold sheeting in place as well as to carry a templet on top of the outside piling, which was used to hold vertical reinforcing rods in place and column anchor bolts, piles were driven on the outside of outer ring and inside of inner ring. Four piling between each set of columns on outer circle and three[1] on inner circle. These were far enough back to allow two sets of sheeting to be placed, as the excavation below 4th St. was 22 ft.

Piling should be heavy enough to drive the lower or small end several feet below the intended excavation and strong enough to hold back the earth when sheeting is in place; in our case the tops were 12 in. to 14 in. and 40 ft. long, some 50 ft. long were driven on the outer ring next to alley where three sets of sheeting were required. As the excavation progressed braces were placed between the piling every 6 ft.

[1] Would make inner circle four piling on a similar tank as the diagonol bracing at column points interfered with removing the dirt from excavation.

After both walls of tank were finished the piling was cut off a foot below the mound level and mound leveled up over them and tamped. On the outside ring they were cut off



Drawing No. 4.

below grade of yard level. 74 pilings were used for constructing purposes only and no piling whatever were driven under annular walls for foundation purposes.

Sheeting and Timbering.

Photo. No. 4. *Drawing No. 4.*

Sheeting was placed as the excavation of annular ring

Photo No. 4.

Shows timbering on the south around annular ring and upper sheeting nearly all in place, as well as lower sheeting started, the top of which is shown directly below where man is standing.

progressed and was driven by hand labor with a maul, in the

same manner as you would in ditching, the timber for stringers and braces being handled with the derrick and lowered into the ditch and placed by hand: 6 in. by 6 in. were used for stringers on the top course of sheeting and 6 in. by 8 in. in the lower course, also 6 in. by 6 in. for braces on top course and 8 in. by 8 in. on the lower course.

The sheeting was all 2 in. by 8 in. by 12 ft. sharpened chisel shaped on lower end with the flat side facing out.

All sheeting was available for use after tank was completed and removal of same is described under excavating.

Excavating and Filling.

All excavating was done by hand the first 6 ft. loaded into wagons. When water appeared in the excavation sheeting was then placed and dirt shoveled into a scale and hoisted out with the derrick. The derrick dumped dirt into chute and was held there to be dumped into the wagons by gravity and hauled to the City dump a mile away.

The first or upper section was 16 in. wider than the lower section, and after the first 11 ft. was excavated the second set of sheeting was started, on the inside of the first sheeting, as shown on drawing No. 4.

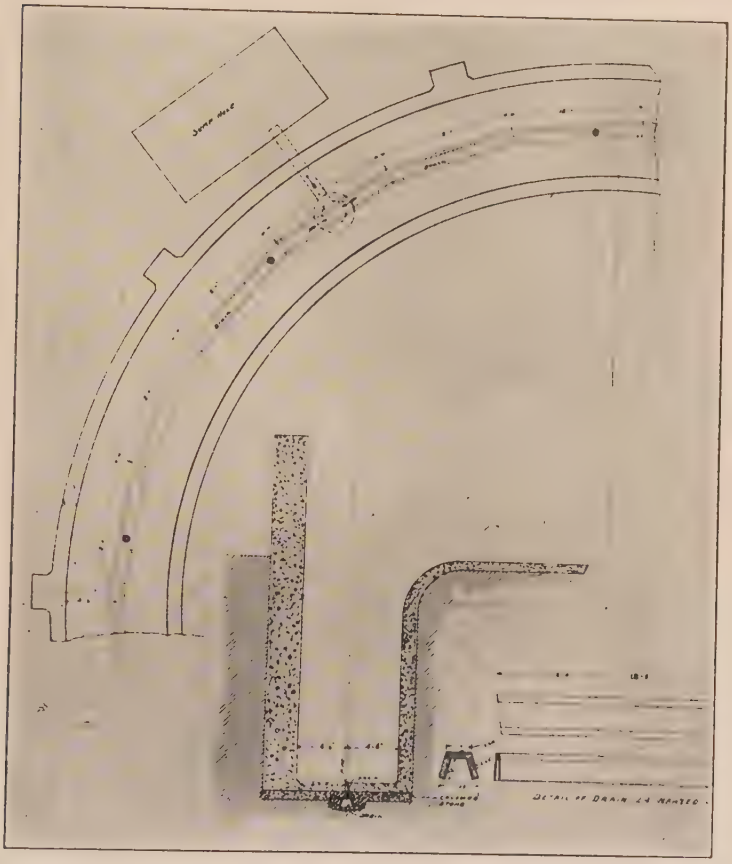
On account of the water encountered we kept a grade towards the sump hole, that is the low point of the excavating was held at the sump hole and a slight grade up from this point to the right and left of the annular ring and in this way the dirt was kept fairly dry for handling.

After the concrete tank was completed above lower sheeting, dirt was filled in between the inner sheeting and the mound and the outer sheeting and the dirt backing and the lower sheeting pulled out by aid of an ordinary sheeting puller several planks at a time, all of which, as well as the bracing and stringers were available for use and were sold for what we paid for it, caused by an advance in the price of lumber.

Drain for Water.

Drawing No. 2. and 5.

When excavation reached a material that I deemed sufficiently strong to hold the weight of the tank, water and guide frame, an excavation for a drain was made in the center



Drawing No. 5.

of the annular ring 2 ft. wide, the high point of which was diametrically opposite the sump hole, crushed rock a few inches deep was laid in the bottom of the excavation and a

three sided wooden drain carefully fitted leveled and placed on top of the rock with the open side down. The rock and drain had a fall from the high point to the right and left towards said sump hole, and crushed rock covered the sides and top sufficient to clear the bottom of tank 6 in. At ten points in the circumference of the drain 3 in. openings were bored through the top of the drain, a 3 in. railing floor flange bolted to the box over the holes and a 3 in. nipple threaded both ends, one end screwed into the flange the other or top end having a 3 in. socket and plug. These pipes were cut to a length that the top of sockets would come level with the finished bottom of tank. The plugs were left out during construction, that the pressure of water could be relieved from the underside of the concrete in case of a heavy rainfall, stoppage in pumps, or drain.

The two ends of this drain emptied into a small concrete pit 2 ft. in diameter, in center of annular ring and into this pit at the side connected the 12 in. sewer pipe described before, leading into sump hole. The top of this pit was left open until bottom of annular ring was finished for the purpose of cleaning the drain if necessary and a reinforced top closing the opening, before finishing the tank bottom at this point.

Inlet and Outlets.

One 30 in. inlet and two 24 in. outlets were supplied, laid below the tank bottom and drain and the standpipes inside were placed a few feet inside of the inner ring of tank, an excavation being made for each in the mound. Concrete was placed around these pipes, including the drip pots from the ground level on the outside of the tank to the top of mound on the inside, the space in excavation not occupied with the pipes and concrete was filled with dirt and thoroughly tamped.

Forms.

Photo. No. 5. *Drawing No. 4.*

Eight sets of forms were made as follows:

2 for inner wall.
2 for outer wall.
2 for columns outside of the outer walls.
1 for walk around.

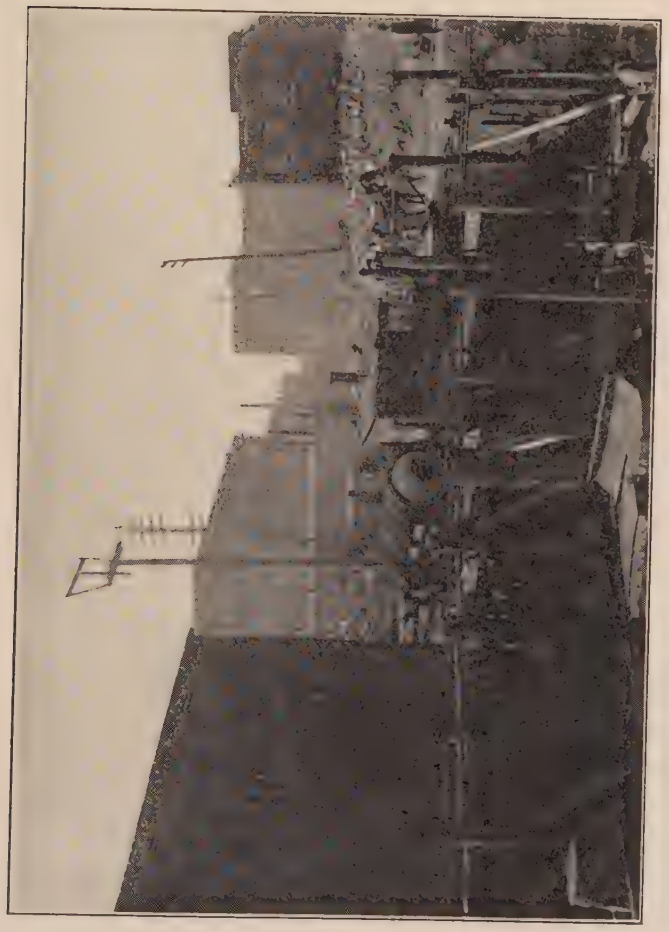


Photo No. 5.

Shows " Smith mixer " and engine in place above alley level. One 24 in. outlet standpipe in place up through the mound, and forms piled on mound ready to be placed.

Each set of circular forms were made 4 ft. high as a unit of four usually works out well in any system of work.

One complete circular set was made for the walk around and the inside circle next to the mound, and two complete sets for all the others. This was necessary in order to keep the carpenters placing forms while concrete was being poured. These forms were placed so that the outside circle was about 2 ft. higher than the inside circle, and vice versa and only 20 in. to 22 in. of concrete was poured at a time. This also was a benefit in keeping carpenters at work and produced less strain in holding forms in their place by too much weight of concrete against them at one time.

Walk Around

Photo. No. 6.

Level with the top of intended finished tank 3 in. by 12 in. planks were placed across annular ring and bolted to inner and outer piling. These acted as braces for the piling, as well as joists to rest the walk around on. The walk consisted of 3 in. by 12 in. plank cut to a mitre, spiked to each joist and placed directly over the outer wall of tank. These planks were dressed on top side and when circle was completed a circumference line was inscribed with aid of tram the exact diameter or position of the ¾ in. vertical rods in the outer wall. On this line at intervals of 2 ft. ¾ in. holes were bored, through which the top end of vertical rods passed and were held in place, as well as two of the 2 in. anchor bolts for columns the rest of the column rods being held in place by a special frame or center nailed to said walk around.

Anchor Bolts.

Photo. No. 7. *Drawing No. 2.*

There were 40, 2 in. anchor bolts for the columns, 33 ft. long, 4 bolts to each column with each bolt up-set to 2¼ in. on one end 5 in. of a thread cut for 2¼ in. hexagon nuts, thus getting a full 2 in. bolt. These bolts were hung from the templet or walk around so that all the thread would be above

the finished tank top, the lower ends of the bolts rested on a light base of concrete at the underside of or below the annular

Photo No. 6.

Shows joists connecting piling across annular ring and the walk around or center nailed to joists directly over position of outer annular wall, also pipe and specials for inlets and outlets.

ring. The bolts were set plumb and built solid in the concrete piers. No piping being allowed around the bolts at the top

to be filled with concrete after the guide columns were placed, but set solid in their place. When the holder columns were

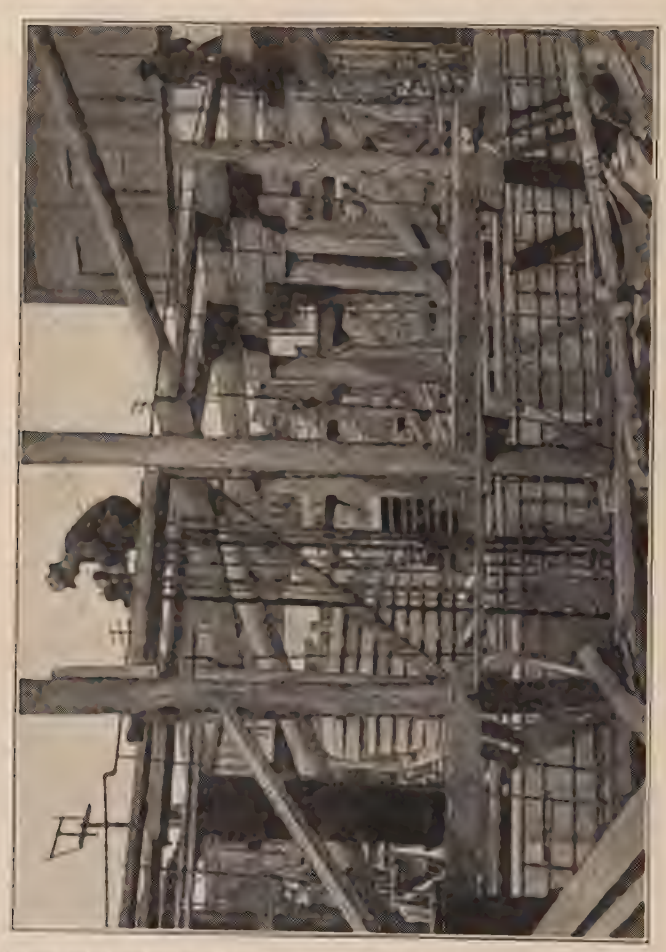


Photo No. 7.

Shows reinforcing 1-¼ in. horizontal rods in place above grade. The ¼ in. vertical rods extending through the walk around also the 2 in. anchor bolts and 1 in. vertical rods for one of the piers for column, all extending through the walk around. One 24 in. outlet pipe finished. The boom of derrick shows at upper right hand corner. The man is placing a nut on anchor bolt. The ¾ in. rods around the 2 in. column bolts can also be seen close to bottom of photograph.

placed, every bolt cleared the bolt holes on the base of the column and no trouble was experienced by the holder contractor in placing any part of the guide frame.

I mention this particularly to show that the bolts can be built and held to the exact center if ordinary care is taken during construction, and therefore getting a guide frame placed plumb in every way.

Reinforcing Rods.

Photo. No. 7 and 8. *Drawing No. 2.*

The rods were ⅜ in., ¾ in., 1 in. and 1¼ in. The ¾ in. being used for verticals and across bottom of annular ring, and around circumference in bottom of said ring. The vertical ¾ in. rods on inner circumference wall rounded over the mound about 10 ft. ¾ in. rods were also used for horizontals on inner wall.

The ⅜ in. rods were used on top of the mound and walk around and were also placed horizontally around the 2 in. anchor bolts in piers at intervals of about 8 in. to strengthen the column piers.

The 1 in. and 1¼ in. rods were used horizontally in the outer wall of annular ring and walk around and 3, 1 in. rods in each column pier from the bottom to top, to help carry the weight of the guide frame and columns.

These rods were mild steel direct from the mills and were about 33 to 36 ft. long, the ultimate tensile strength being 60,000 to 64,000 lbs.

The ¾ in. vertical rods were bent forming an ell (see drawing No. 6.), with the 3 ft. vertical side in the center of inner wall, thence across bottom and up the opposite side in center of outer wall and terminating at top of templet through the ¾ in. holes left in said templet or walk around, alternating with these verticals at one foot centers in the bottom, the 6 ft. vertical side was placed in the outer wall, thence across bottom and up the opposite side in center of inner wall. At the ends of all the rods excepting top end of ¾ in. in outer wall, a hook was turned. The horizontals in inner and outer

walls were placed outside of the ¾ in. verticals with the hooked ends not less than 6 ft. apart. We took particular

Photo No. 8.

Shows south side excavation and sheeting finished. ¾ in. vertical rods placed in inside annular ring and bent over the mound. Also several lengths of cast iron pipe for inlet and outlet pipes.

care not to hook the ends prefering to leave concrete between the hooks of the lapping ends which adds strength in addition

to adhesive surface of concrete on the rods, all of which is necessary to keep them from pulling out at the lapping points. These rods were spaced as nearly as possible, as per drawing No. 2 and were wired to vertical rods where necessary to hold them in place, a light annealed wire being used for this purpose.

The horizontal rods were placed before the forms were set, but never above the forms as they would interfere with the pouring of the concrete.

All rods used were round and should not be otherwise as the concrete will not always cover rod on underside, if other than round.

Anchor Wall Plates.

Drawing No. 7.

Wall plate anchors were placed and bolted in the inside of the forms opposite the columns and half-way between columns, 20 vertical rows in all, for the purpose of bolting the guide rail plates to when tank was completed. There were six wall plates to each vertical row. Great care must be taken in placing these in line and that the face of all plates are equal distant in a radial line from the center of tank.

Wall Plates.

Drawing No. 7.

The wall plates for the outer sections are ¾ in. by 6 in. flat iron and were fastened to the anchor plates as follows:

A ¾ in. hole was drilled in each plate opposite the slot of each anchor wall plate and the hole reamed out on the outside of plate or the side on which the roller traveled for the head of the bolt.

A ¾ in. plow bolt with slotted head, passed through these holes leaving the head of the bolt flush with the face of the wall plate, then through the slot in anchor plate and screwed into a nut 3 in. long and 2 in. wide, which slipped into a recess in this plate back of the slot left for this purpose. The wall plates were then plumbed and backed with concrete mortar, also the recess and slot in wall plate filled with mortar.

Test No.	Tensile strength per square inch on average of five samples					Tests steaming and boiling		
	Neat cement			1 cement, 3 sand				
	24 hours test	7 days test	30 days test	7 days test	30 days test	24 hours air	3 hours steaming	3 hours boiling
1	421	787	897	314	407	Good	Good	Good
2	465	834	892	316	401	"	"	"
3	413	786	850	300	435	"	"	"
4	428	836	—	287	—	"	"	"
5	415	827	—	290	—	"	"	"
6	416	829	—	287	—	"	"	"
7	379	811	—	313	—	"	"	"
8	361	875	—	281	—	"	"	"
9	382	922	—	303	—	"	"	"
10	403	870	—	295	—	"	"	"
11	263	778	825	357	408	"	"	"
12	403	809	—	304	—	"	"	"

Test No.	Test for fineness. Per cent. passed through screen			Time for setting in hours and minutes		Test for rise in temperature in 15 minutes	Test for setting in cold water
	100 mesh	74 mesh	50 mesh	Initial	Final		
1	94.0	98.8	99.6	1:55	3:05	70° to 75°	Good
2	92.8	97.3	99.3	1:50	3:15	71° to 76°	"
3	92.0	96.6	99.3	1:50	3:05	72° to 77°	"
4	95.4	98.5	99.6	2:05	5:40	70° to 74°	"
5	95.7	98.6	99.7	2:50	5:45	70° to 74°	"
6	95.5	98.8	99.7	3:05	5:55	70° to 74°	"
7	95.0	98.4	99.7	2:55	5:20	70° to 74°	"
8	93.7	97.8	99.7	2:50	5:10	71° to 76°	"
9	94.3	98.2	99.8	3:05	5:15	70° to 75°	"
10	94.3	98.2	99.8	2.55	5:15	70° to 75°	"
11	96.5	98.9	99.8	3:55	5:50	70° to 74°	"
12	96.5	98.7	99.8	3:05	5:15	71° to 74°	"

The essential materials for good concrete well known by all are:

Rock or gravel,
Sharp sand,
Portland cement,
Water.

We decided on using a "Binder" rock, of a size of which runs from small chips up to possibly 1¼ in. cubes. We would have preferred good washed gravel, but this was not obtainable.

Sharp sand needs no description.

The cement should be carefully tested, which we had done at the City testing plant.

The table of tests are on pages 22 and 23.

Each test number represents one carload, all of which was accepted and used in the tank.

No 11 on 24 hour test not showing as high as others was held for 7 day test before using. This carload was fresh from the mill, thus accounting for low tensile test in 24 hours.

Mixture of Concrete.

Drawing No. 8.

The next point to be decided was the proportions of materials. We decided to make a test on two slabs. The first 1, 2, 4 mixture the second 1, 3, 4 mixture. For this purpose we made two boxes, 3 ft. long 1 ft. wide and 1 ft. deep inside, two batches of concrete were measured as per above mixtures and placed in the two boxes which made two slabs of concrete 1 ft. wide, 3 ft. long and about 6 in. thick. These were allowed to set six months when the boxes were removed and a test made for strength by weighting until they broke, with the following results:

No. 1 or 1, 2, 4, mixture 2900 lbs.
No. 2 or 1, 3, 4, mixture 6276 lbs.

We therefore decided on using the No. 2 mixture as the mortar of sand and cement evidently added to the strength and was closer in every way, no voids appearing and as a

water tight tank is necessary, the mixture proved at the finish we decided wisely.

Before pouring any concrete we covered all the bottom of the annular ring between the sheeting with crushed rock, probably 8 in. thick and leveled the same, the rock was then tamped down with a heavy tamper, on this rock the concrete was poured to the required depth for the bottom of annular ring. This rock prevented the concrete from sinking into the earth and served as a passage for the water to perculate and reach the wooden drain as described in Drawing No. 2 and 5.

Mixing and Pouring.

Photo. No. 5 and No. 10.

For this purpose a Smith mixer was used and was placed at the northwest corner of the site a little above the alley grade. About ½ cubic yard was mixed at a time and every foot of material for each batch was measured and placed in the mixer and water measured with a bucket and thrown in with the material.

Just above the mound and over the annular ring a light track was laid for carrying iron dump cars "V" shaped which dumped either side. Into these cars the mixed concrete was dumped from the mixer and carried around the tank and dumped into a chute and into place between the forms of both the annular rings. This method was used up to the top of the mound.

For the bottom of the annular ring, top of mound and the outside of the annular ring above the mound, the concrete was dumped from the mixer into an iron bucket in the shape of an inverted cone, with a quick closing hinged lid on the bottom. At the top of the bucket three chains were fastened to the circumference and brought to a ring in the center 4 ft. above the bucket; this was hung from the ropes of the derrick boom, and swung to any point desired, the lid opened and concrete dumped.

On account of the vertical rods of tank walls being in the way, a few sections of 6 in. pipe, flanged at the ends, were

made of sheet iron 4 ft. long with the lower section curved and top section hopper shaped into which the concrete was

Photo No. 10.

Shows view taken from same place as No. 9 photograph. Form removed at extreme left, exposing top of finished outside wall, also inner tank piling removed. One 24 in. standpipe is shown. Concrete dumping from hopper hung from derrick boom. Man has hold of catch for lid on hopper. Concrete being poured on top of mound from outer edge towards center. Grade stakes for top of concrete are also shown. More reinforcing rods are yet to be laid in mound center back of men.

dumped, and landed in place. (See drawing No. 9.) These chutes were light and easily handled and as each form or 4 ft. was filled, one section of pipe was removed. Four of these chutes were used so there was no delay placing concrete.

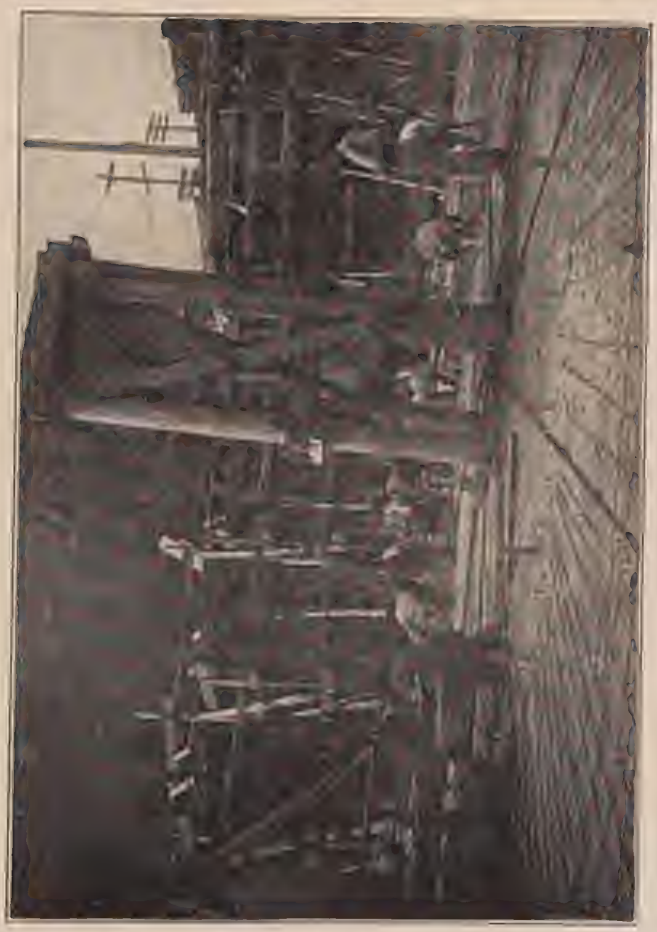


Photo No. 9.

Shows outer wall finished with inside forms still in place and men laying out rods on top of mound. Piling for tram shown in center. Bull wheel of derrick shown to left. Men facing top side of the inner finished concrete wall.

MOUND.

Photo. No. 9 and 11.

To finish the center point the tram was removed, all four piling around center were cut off one foot below mound level, a hole was excavated one foot deep and of dimensions suffi-

Photo No. 11.

Shows section of completed tank. Top of outer ring at upper left corner. Mound finished and man's head is shown as he ascends the ladder out of the annular ring. The cables belong to the derrick, but go over the top of the outer wall not shown in photograph.

ciently large to clear outside of piling and the excavation filled with concrete with a few reinforcing rods on top of this foundation the ⅜ in. reinforcing rods of the mound were lapped over and the concrete top of the mound covered these rods.

Center Pier.

Photo. No. 12.

An old piece of 42 in. diameter smoke stack which we cut to required length we used for an outer form and placed a core in the center 26 in. diameter made of 4 in. strips nailed to several circular pieces of wood 24 in. diameter for the inside form and concrete was poured between the two forms for the pier, with a cap stone on top 30 in. in diameter. On top of this cap stone rested the crown sheet of the holder. On top of the mound and set in the concrete at required points, we placed straps of iron vertically two at each point, to bolt the wooden columns of permanent staging to, to support the crown of the holder. These can be seen in photograph No. 11 and 12.

Both sides of the vertical walls, the top of mound and bottom of annular ring of tank were brushed with a wash made of neat cement to make tank water tight. This coating was liquid in form and was applied to the concrete before it had dried out, in the same manner that white wash would be spread with a brush.

Filling Tank.

Photo. No. 13.

When holder was finished the tank was cleaned out and 3 in. plugs were placed in sockets at openings of the 3 in. pipes connecting to drain in the bottom of annular ring and a small mound of concrete placed over the plugs.

Water was then turned in to the tank from two of the City fire hydrants and when the water reached 4 ft. in height the pump in sump hole was shut down and water allowed to accumulate in drain and sump hole standpipe. In eight

hours the water in the tank had reached to the top of the mound when it was shut off, a record of the height of water

Photo No. 12.

Completed tank with shell of inside section finished, waiting for top curb angle. Wooden planks are on top of the concrete walk around with scaffold for holder men, hanging over the top of walk around. One full column pier is shown. The 30 in. inlet standpipe both inside and outside and one 24 in. outlet standpipe. The pipe in center is the outside form for concrete center pier not completed.

taken and allowed to stand until the following morning when an examination was again made of the water line, which was found to be at the exact height as the night before, showing

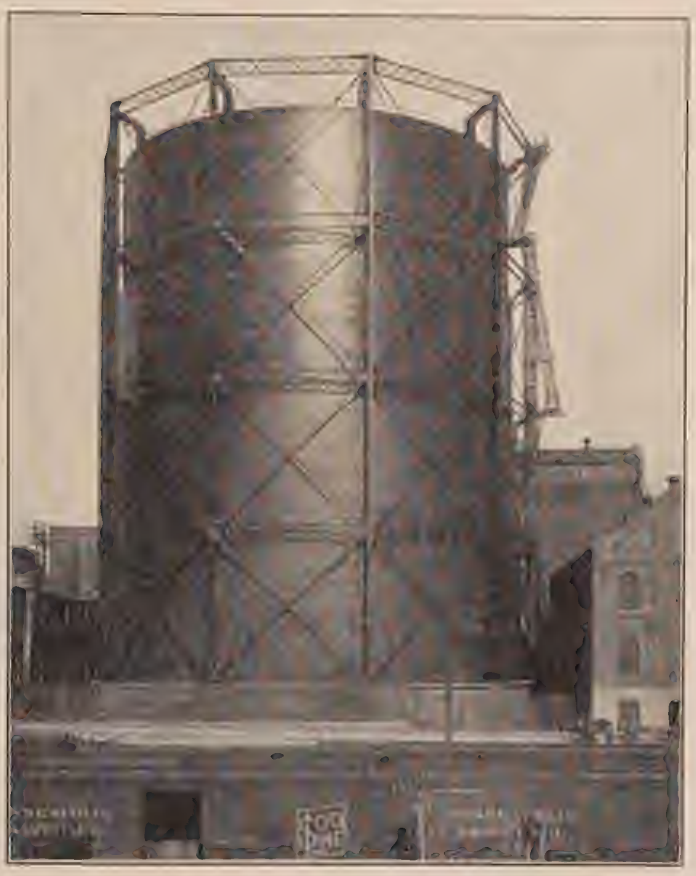


Photo No. 13.

Shows south exposure of holder and guide frame finished and in commission, with walk around concrete tank, shown just above the fence. A stone wall on property line of 4th street to hold grade level and carry fence. Building to right and east of holder constructed after completion of tank and holder. Building to left and west same as shown on photograph No. 1 not on our property.

there was no leakage in the annular ring to top of the mound. Water was then turned on again and the filling of same up to the tank overflow was finished in eleven hours. The water was allowed to stand in tank without any further filling for five days and as no perceptible leakage could be found up to this time we proceeded to test holder with air. This tank has been filled since October 5th, 1906 and not one drop of water has ever been pumped into it since. The tank is absolutely water tight notwithstanding it has been subjected to temperatures ranging from minus 30 degrees to 110 degrees on the outside ring, for some nine feet above grade level of the entire circumference with the exception of fifty feet to the west adjoining the alley, while the inside of tank must be above freezing.

A Few Notes.

Work was started driving piling on July 29, 1905 and October 23d, we started mixing concrete and finished bottom of annular ring October 28th. Numerous delays caused by strike on railroads, rain, etc. made the actual working days to this time only 60. When freezing weather set in we suspended operations for the winter.

All pumping was stopped and water allowed to rise in annular ring some 16 ft., which froze over on the top and the concrete in bottom was protected by the water.

March 19, 1906, we again took up operations and started pumping out the water. After this was finished an accumulation of mud had to be removed from the bottom. The weather remained cold (below freezing) so that we only got started on pouring concrete on April 17th in the afternoon and the tank was completed May 31st and allowing for Sundays and rain the actual time constructing the tank was 40 days.

The total working days then were 95 days or about 3 months, not counting the time of closing down and starting in the spring.

The derrick was left in a few days to lower the iron into the pit for holder contractors.

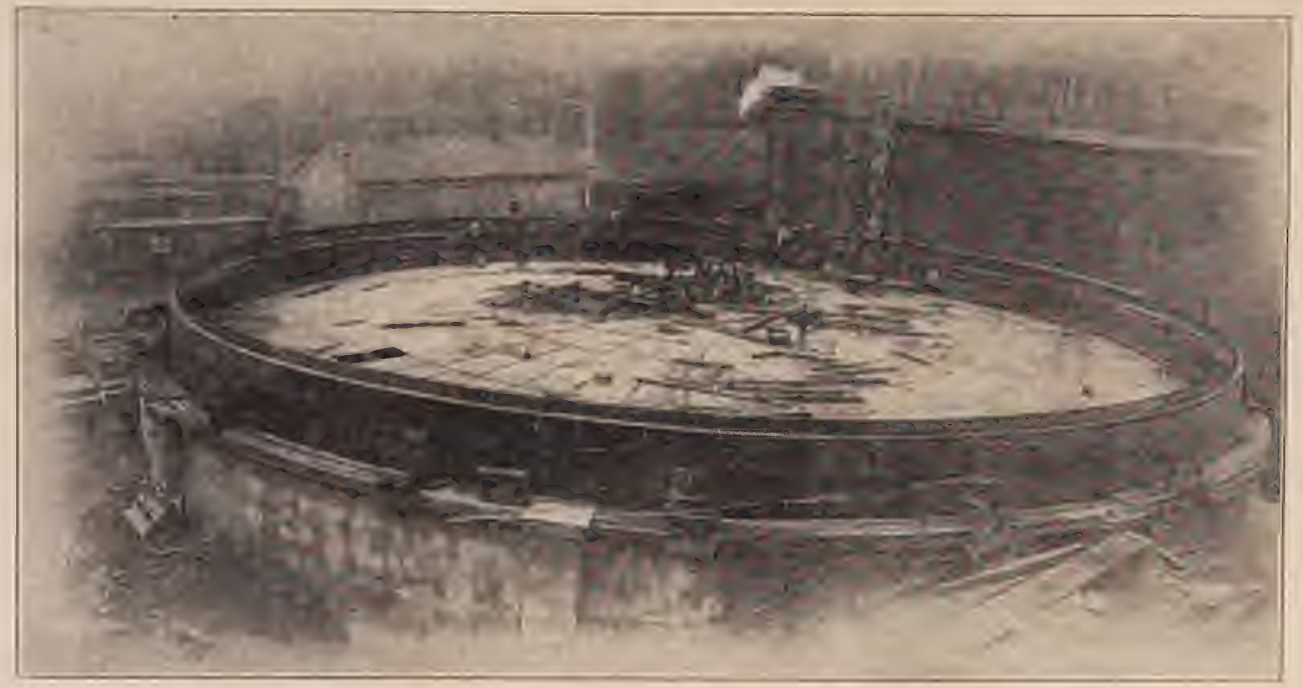


Photo No. 14.

Shows tank walk around with lowering jacks fastened to it. Second section of holder hanging to the lowering jacks. The men on the far side of the photograph are just placing the last piece of iron to finish the grip and dam sheet. The crown of holder is finished with exception of a few sheets left out for ventilation.

Photo. No. 14.

The concrete walk around was used to rest lowering jacks on and were clamped to the walk around and the outer sections were each hung from them during construction, the riveters using the curb sheet of inner sections to stand on. This saved an expensive staging on the outside of tank.

The mound which is 78 ft. 6 in. in diameter proved to be an excellent place to store material during construction of tank and holder, carry derrick or excavating machine, etc.

The gallons of water to fill this tank 31 ft. in depth were 971,850: if mound had been removed would have required 724,040 gallons more or 1,695,890 total, considerable more to be pumped and kept from freezing in the winter.

A tank below ground is safer and better than a tank above ground and can be constructed as cheap as a steel tank above ground; will last practically forever if constructed of concrete and requires no painting or repairs after completion. Anchor ice is unheard of, exhaust steam can be used to heat the tank and less exposure to storms, easier of access and numerous other advantages over an above ground tank.

Some Units of Costs.

In large units and where there is sufficient room to deliver all material in carloads, close to the work on hand, machinery used for the bulk of the excavating, and dirt dumped around the circumference of the tank, the costs at prices prevailing to-day would be about as follows:

	Cents
Excavating per cubic yard	.25
Piling other than Cedar up to 40 ft. lengths in place per lineal foot	.32
Timbering and Sheeting for holding sides of excavation in place per square foot of walls or excavation braced, material 4.5 board ft. of lumber at $30.00 per M.	.135
Labor placing and removing timber and sheeting	.03
Total	.165

	Cents
Forms. It requires 6.5 board ft. of lumber for each face ft. of forms at $40.00 per M. costs	.26
Carpenters labor and machine time for each face ft.	.04
Total	.30
or described in another way: 1 ft. of a cross section of vertical walls requires 30 face ft., which equals 195 board ft.	
In this tank (where forms were required) the cost for forms and braces for each face ft. of finished concrete is	.0857
Labor handling forms, braces etc.	.0667
Total	.1524
In larger units where depth of tank is over 32 ft. there will be a decided reduction in cost per face ft.	
The cost for forms, bracing, handling, etc. in walls 16 in. thick per cubic ft. of concrete placed	.229
Per cubic yard	6.18

These figures seem high, but they also would be reduced where the walls are thicker.

Concrete mixed in proportions of 1, 3, 4 will make one-fourth more than the rock measures, that is the sand and cement equals one-fifth of the finished concrete the rock four-fifths. The weight of a cubic foot of this concrete when four months old is 126 lbs. The labor required for mixing and pouring will cost $2.30 per cubic yard.

Reinforcing iron at $40.00 per ton; the cost for material will average about $2.45 and labor shaping and placing 0.72 cents per cubic yard of concrete, that is for this tank. The cost for iron will be increased in larger units.

There are other costs such as laying or placing inlet and

outlet pipes, liability insurance, making and placing tram, making concrete bucket, rubber boots, steam pipes and numerous sundries that will average 10 per cent. to an estimate after obtaining the main costs as numerated.

Before closing I wish to express my thanks to Mr. C. A. P. Turner of Minneapolis for plans of reinforcing, and Messrs H. B. Stiles and Alfred Lideroth of the St. Paul Gas Light Company for plates, and drawings.

THE PRESIDENT: Are there any gentlemen who wish to make any remarks on this paper, or any discussion? If not a vote of thanks will be in order.

MR. ELBERT: I want to make one remark, if there is not going to be any discussion. There has been a great deal of talk about underground tanks and overground tanks, earth backing, etc. I am trying to get some data from the town authorities of Attleboro, Mass., about the reinforced concrete tank that was placed there in 1905 for their water company. This tank, or standpipe, is 50 feet in diameter and 100 feet high; it contains 1,500,000 gallons of water. It is all above ground. The base of the tank is 18 inches thick; the top eight inches thick and the cost of the tank was three thousand dollars less than a steel tank.

A vote of thanks to Mr. Elbert was duly carried.

THE PRESIDENT: The next paper on the list is

PNEUMATIC CAULKING WITH LEAD WOOL OF 30 IN., 36 IN. AND 48 IN. MAINS.

BY MR. C. C. SIMPSON, JR.

MR. SIMPSON: I might mention before reading this paper that if I had picked out the title myself I would have labeled the paper, "Our experiences in caulking those sizes of pipe with lead wool and pneumatic hammers." We do not claim to be the pioneers in getting successful results in this line of

work. I understand the Brooklyn Union Company has done such work and that Mr. Hall of the Central Union has tried it out. I do not claim any credit for the idea. It was suggested by Mr. Bradley, Mr. Hall and Mr. Simpson, Sr., and I was merely given the work to do.

(Mr. Simpson then read his paper.)

PNEUMATIC CAULKING WITH LEAD WOOL OF 30IN., 36 IN. AND 48 IN. MAINS.

The first attempt at pneumatic caulking was made by this Company in the Summer of 1900 on a 30 in. main, the joints being the regulation cast lead and yarn with the depth of lead about 3½ in. The experiment did not succeed for two main reasons;—the first of these being the impossibility of caulking the lead back for more than ½ in. or ¾ in. from the face of the hub, the balance of the joint remaining in the same condition as when first poured. The more pressure applied, the tighter this ½ in. or ¾ in. ring is driven until finally the hub splits. The second reason for failure was the inability to reduce the amount of time taken to caulk the joint. Given the same amount of caulking time for both hand and compressed air joints, the cost of the latter would naturally be higher on account of the operation and depreciation charges on the plant in use.

With the advent of lead wool and its adoption by this Company to the exclusion of cast lead, the question of pneumatic caulking again came to the front. While lead wool joints are more efficient than those made with cast lead, there are two factors which make them more expensive. The first of these factors,—the cost of the raw material, we are unfortunately unable to control. The second factor is, the length of time necessary to caulk the joint. When we consider that it takes two experienced caulkers ten hours to yarn and caulk one 48 in. lead wool joint, it is evident that the labor cost is a rather large item. Anything which will reduce the caulking

time without a corresponding increase in labor will result in a material reduction in the cost per joint.

With this end in view, it was decided early this Spring to make a series of tests on pneumatic caulking, with the idea of introducing it on the large mains to be laid during the Summer. At the time, there was in process at our 111th Street Yard, a school of instruction for lead wool caulkers, and by carrying on our tests at this time and place we were able to secure a very fair comparison between the hand and air work.

For this hand caulking instruction, a number of specially prepared 30 in., 36 in. and 48 in. joints had been set up. These consisted of very short split hub sections held firmly together by wrought iron bands, with spigot pieces four or five feet long inserted in the hubs, the whole joint being firmly held in place by posts and braces. These joints were yarned and caulked, a record of the time kept for each operation, and on completion, the removal of the split hub made it possible to inspect and weigh the lead wool contained in the finished joint. This weight was compared with the average weights of cast lead and lead wool usually contained in a joint of the size in question. In addition to this, a random section of the lead wool was cut out with a hack-saw and its specific gravity obtained to determine how nearly the lead wool has been compacted to the density of cast lead.

Lead wool is caulked in the following manner: The material comes from the manufacturer in strands about ½ in. in diameter and from two to three feet long, each strand being twisted up to about the shape of an old fashioned cruller. These are straightened out and re-rolled until we have a fairly hard strand not quite as thick as it was originally with a slight taper at each end. These strands are caulked into the joint separately, taking care, of course, that the breaks do not come directly over one another, and when the face of the hub is reached the joint is finished off in the same manner as with cast lead. (See Figs. 8 and 9).

The first joint attempted was a 48 in. which had been previously yarned by hand. We used a small gasoline driven compressor of about 50 cubic feet capacity, and were furnished with hammers by the Ingersoll Rand Company, who also sent an expert to give us any assistance necessary. No attempt at speed was made on this joint, as it was necessary to instruct several green caulkers in the handling of the hammers and also to do some experimenting in order to produce a proper caulking tool.

The hammer used was an Ingersoll Rand "Imperial" chipping-hammer, with a 3 in. stroke. The tool which we finally found to give the best results was forged from a 7/8" hexagonal steel tool blank, and was similar in shape to that shown in Fig. 1.

On the completion of this 48 in. joint, the split hub was removed for inspection. The lead wool found to be very well compacted,—the few irregularities being due, no doubt, to the caulker's failure to put enough of his weight against the tool. The yarn had been driven back about 1/4 in. and was hard enough to have made in itself a gas-tight joint. The weight of the lead wool was a few pounds lighter than the average, but taking into consideration the fact that this was the first attempt, and that the caulkers were absolutely unfamiliar with their tools, the result was more than encouraging.

As it was necessary to come to a decision in a very few days, whether or not we should adopt pneumatic caulking, it was decided to make the balance of the tests on 30 in. pipe, this being an average size and taking very much less time to caulk than 48 in.

A 30 in. joint was therefore, yarned up and the Ingersoll Rand representative volunteered to caulk this against time. The joint was completely caulked by this one man in an hour, as against 5½ hours, the average time for hand work. Inspection of this joint showed it to be quite as well compacted

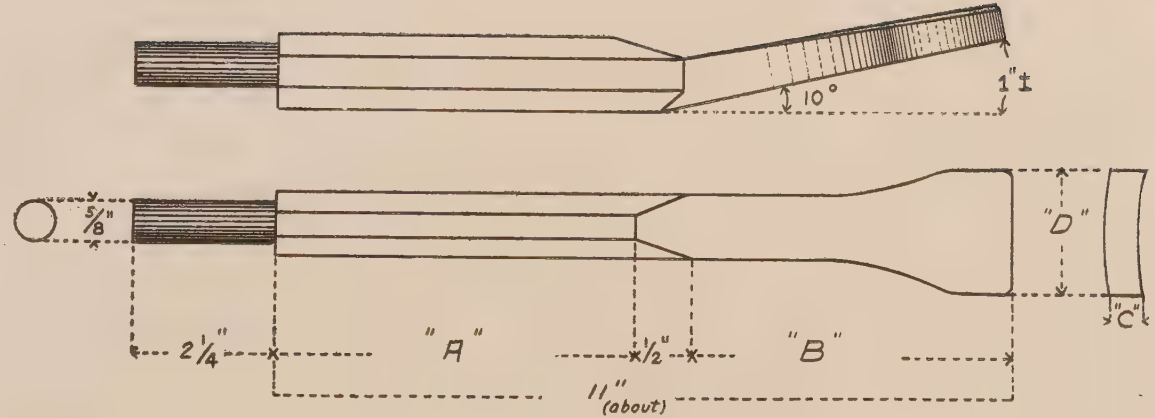


Fig. 1.—Dimensions of caulking tools.

Size of pipe	30 in.				36 in.				48 in.			
	A	B	C	D	A	B	C	D	A	B	C	D
Yarning iron	6¼	4¾	⅜	1⅞	4	6	⅜	2¼	3½	7	⅜	2
Caulking tool No. 1	6¼	4¾	⅜	1⅞	4	5½	½	2	4½	6	½	2
Caulking tool No. 2					4	5	9/16	2	5½	5	½	2
Caulking tool No. 3									6½	4	⅜	2
Finishing tool	6¼	4¾	⅝	1⅞	4	4½	⅝	2	6½	4	1	2

and to weigh several pounds more than hand caulked joints of this size.

An Italian caulker, who had handled air hammers before, was then placed on this joint and supplied with a helper to roll and place the lead wool, enabling him to caulk continuously. Francisco kept at it pretty steadily and finished his joint in 45 minutes. On inspection, it proved to be quite as good as the first, with the exception of being about four pounds lighter. No attempt was made at pneumatic yarning as we had, at the time, no tool blanks of sufficient length to forge out a set of yarning irons. We decided, however, to try this out during the Summer's work, and I might add here, that it has been more than successful. The information obtained by these tests was then placed before the head of the Department of Mains and Services. He decided that the scheme was worthy of an extensive trial under working conditions, and authorized the purchase of two portable compressors with sufficient tools and equipment for each to work a gang of six caulkers.

There were a dozen or more makes of portable compressor outfits on the market, any one of which would probably have answered our purpose, though unfortunately, no one of them had been used before on this sort of work. The ideal outfit to meet the working conditions should embody the following main features:—

Light Weight—so as to be easily moved from one place to another without the aid of horses.

Self-Contained Water Cooling System—the cost of a hydrant connection in New York City is about $4.00 per day.

Simple Gasoline Engine—Gasoline is cheap and easily obtained and most gasoline engines may also be run with gas. Steam is too expensive for an outfit of this size and as both direct and alternating currents are used in different parts of New York City, two sets of motors would be necessary if an electric drive were adopted.

Air Capacity of about 50-75 Cubic Feet—this will take care of seven or eight hammers—the maximum necessary to use under average working conditions.

Moderate Cost—the more expensive the outfit, the greater the depreciation charge, which in turn naturally affects the cost per joint.

Fig. 2 is a tabulated statement showing the cost, air capacity, etc., of the different outfits investigated. We finally placed an order for one of the Abenaque-Ingersoll Rand Type (No. 1 on the table) and one National Brake and Electric Company Outfit (No. 6 on the table). The Abenaque-Ingersoll Outfit is shown in Fig. 3, and the National Brake and Electric in Fig. 4. It will be noted that these two outfits are radically different,—our idea being to try out both types and adopt the more successful of the two for future installations. The hammer adopted was the Ingersoll Rand "Crown" chipping-hammer, having a piston stroke of 3 in. With a gang of eight caulkers working, it is necessary to have ten of these tools. Then, if a caulker has any difficulty with his hammer he is given one of the spare tools and the trouble, usually nothing serious, can be remedied by either the foreman caulker or the compressor engineer. Fig.5 shows two of these hammers and some of the experimental tools, the three on the right hand side being those finally adopted.

We had some little trouble at first with these hammers, due no doubt, to the lack of experience on the part of the men handling them. The barrels became loose after working for an hour or so, allowing some of the air to escape, and several of the handle bolts snapped off. We were unable to find the reason for this ourselves and complained to the manufacturer. An expert was sent up on the work from the factory to investigate, and reported as follows:—

"I found four hammers at work on the job all with loose handles, which, from watching the operators,I am satisfied was caused by failure of the men to hold the hammers up hard against the tool while working. This caused the

Fig. 2.

STATEMENT SHOWING COST, AIR CAPACITY, ETC., OF DIFFERENT TYPES OF PORTABLE COMPRESSORS.

Make of outfit	Cu ft. free air per min. del'd	At press. of	Weight complete	Type compressor	Comp. cooling system	Motive power	Cooling system	Cost complete	Remarks
Abenaque	78	100	7700	8x8 Ing.-Rand "NE-I" single stage water jacketed	4 water cooling tanks with rotary circulating pump	15 h-p. 1 cyl. Abenaque gasoline	4 water cooling tanks	$1425	Highly recommended by users
Abenaque	64	100	7800	6x8 Franklin single stage water jacketed	do.	do.	do.	$1325	Well spoken of though Abenaque people claim to sell more of the I. R. type
Chicago Pneum. Tool Company	70	90	over 7000	6x8 Franklin single stage water jacketed	Water circulation	1 cyl. Chicago Pneum. Gas & Air cyl. are cast in one piece and work in tandem with a single piston rod	Water circulation	$1250	More or less experimental—No outfits of this type in market at time we purchased
Fairbanks Morse	70	80	8900	8x8 Fairbanks Morse	Water circulation from tanks	12 h-p. 1 cyl. gasoline	Water circulation from tanks	$1120	Could obtain no data from users
Bury	94	90	9000	9x8 Class B. B. Bury	Water circulation from tanks	20 h-p. gasoline 1 cyl.	Water circulation from tanks	$1825	Rather heavy—unable to obtain recommendation from users
Nat'l Brake & Elec. Co.	100	90	8000	7½x9 3 cyl. Nat. Brake & Electric	Water circulation with radiator	4 cyl. gasoline marine type 27 h-p.	Water circulation with radiator	$1900	Users of smaller sizes speak very highly of same. This outfit built specially for us

piston to strike the front end of the hammer, which resulted in the shock being transferred to the thread on

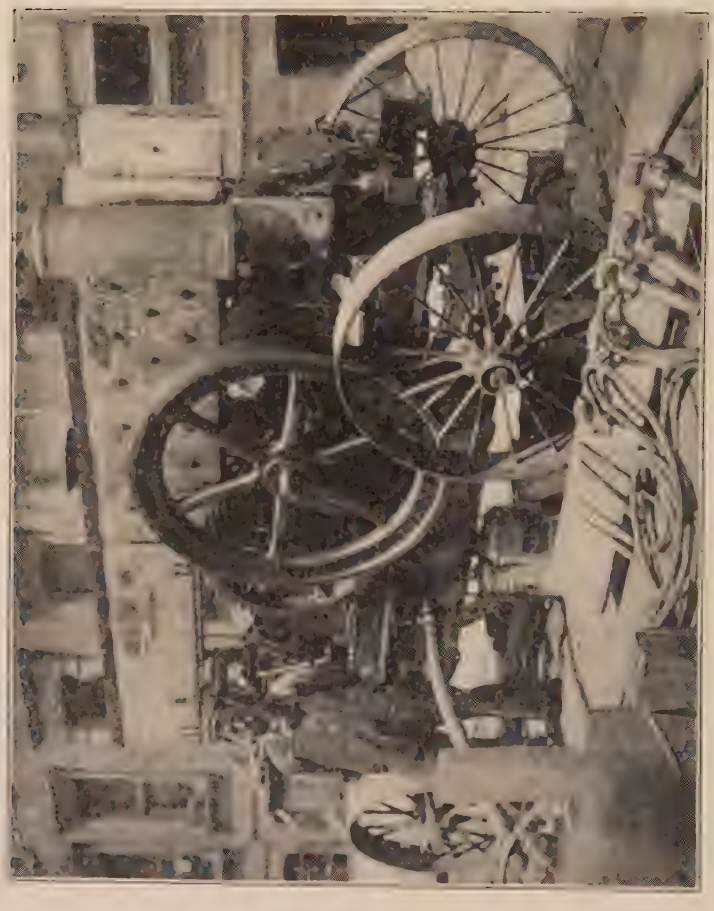


Fig. 3.

cylinder and handle, thus causing an expansion of the handle.

Relative to the breakage of bolts, I removed the bolts that were in the hammer and replaced them with nickel steel bolts brought by me from the shop for this purpose, and by placing the lock washer under the head of the bolt instead

of under the nut, I found that it gave the desired results, i. e., a tight handle, as after watching the tools for three

Fig. 4.

hours longer in actual service, I found that none of the handles came loose.

The split handle complained of was the result of the same cause, inasmuch as the constant jarring had split the handle and the constant tightening of the bolt under the split handle caused it to spread. I would recommend

that these broken handles be replaced and will endeavor, on future orders for this Company, to supply the handle

Fig. 5.

bolts of the kind I have used with lock washers under head and nut."

Very little difficulty of this kind has since been experienced with the hammers. Their work has been quite satisfactory

and the troubles we do have can generally be traced back to a green or inexperienced caulker. The yarning and caulking sets were forged by our own blacksmith from a special 1 in. octagonal steel tool blank eleven inches long. Fig. 1 shows the shape and dimensions of the tools used on the different sizes of pipe. These tools are the product of quite some experimenting with different shapes and sizes, and give excel-

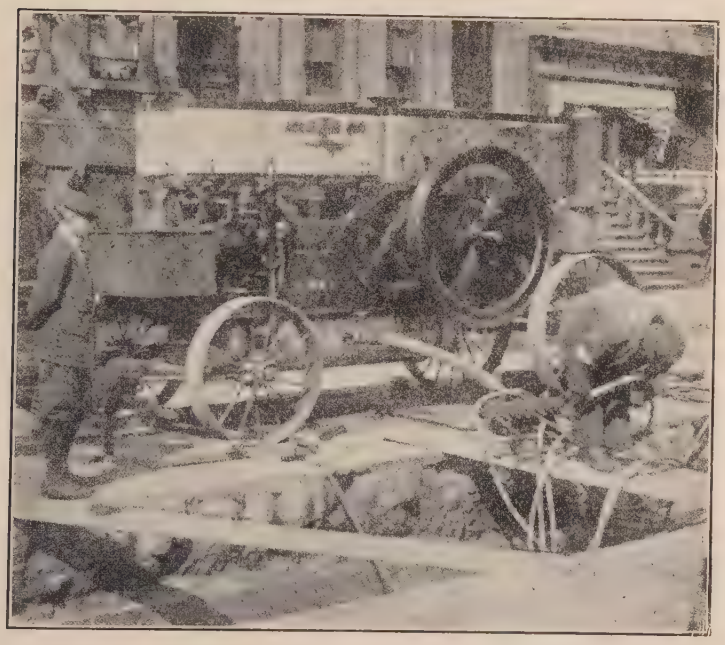


Fig. 6.

lent results. As different joints of any size of pipe vary considerably in width, it is necessary to have several caulking sets with different thicknesses of face to meet these conditions. The broad faced finishing tool is only used in facing off the last strand of lead wool.

Where it was possible to place the compressor alongside the trench near the joints to be caulked, the tool hoses were all run

from a manifold tee (which shows in the lower left-hand corner of Fig. 3). This manifold was in turn connected to the air receiver by a 3 in. rubber hose. This plan is much more satisfactory than that of running a long wrought iron pipe line,—the friction and air leakage losses being reduced to a minimum. Of course, there were cases where it was impossible for the compressor to stand alongside the trench, and the wrought iron line consequently had to be run. Figs. 6 and 7 give a very good idea of the manifold and rubber hose connections.

Fig. 7.

The first gang of compressed air caulkers was started on a 48 in. line. The men were allowed to go along slowly at first until they became accustomed to the work and no cost figures were kept for two or three weeks.

A certain amount of trouble was anticipated at the start, as men of this class are naturally opposed to anything tending

to reduce hand labor and will try in their own quiet way to do

Fig. 8.

what they can to "Beat the Game." And they did for a short time.

As first organized, the gang consisted of nine caulkers, eight of them working in pairs and one acting as a foreman—

his duties being to assign the men to their joints and to inspect the finished work. There were also two laborers rolling the lead wool for the caulkers and a compressor engineer. After several weeks work with this organization, a cost report--given in detail below—was turned in. This report covered the last three days only of the third week's work:

[1]Number of joints yarned and caulked.....	19
Caulkers—@ 30 cents per hr.	$ 91.00
Laborers—rolling lead wool@19 cts. per hr.	11.40
Compressor engineer @ 30 cts. per hr	9.00
Total labor cost	$110.40
Gasoline—29 gals. @ 11 cts.	$3.19
Lubricating oil, ½ gal. @ 50 cts.....	.25
Repairs and renewals	——
Total cost	$113.84
Cost per joint	$5.99

Average time taken to yarn and caulk joint ..6 hours.

To this figure must be added a depreciation charge on the plant in use, of about 30 cents per joint. This is, of course, a very hard figure to determine absolutely. If we take the cost of the plant complete as $1900.00 and figure that it will last for six years, and average 1,000 joints per year, the depreciation cost per joint will be as stated above. Adding this 30 cents, gives us a total cost per joint of $6.29. To complete 19 joints in three days by hand, would mean a gang of twelve caulkers and a foreman with some overtime. The cost per joint would figure as follows:

380 hours caulkers @ 30 cts.	$114.00
60 hours laborers rolling lead wool @ 19 cts..	11.40
32 hours foreman @ 30 cts.....	9.60
Total cost	$135.00

[1] All yarning done by hand.

Cost per joint—(hand)	$7.11
Cost per joint—(air)	6.29
Saving air over hand—per joint	.82

While there was an actual saving of 82 cents per joint, it

Fig. 9.

was nothing like the result we had expected, and it was

decided to observe the work more carefully and see whether it was not possible to cut the cost still further. A little personal investigation developed the following points:—

The foreman being a caulker himself and naturally in sympathy with his men and their desire to "beat the game," was making no attempt to push the work and had finally established a rule that one hammer to each pair of caulkers was all that was necessary. Consequently, one man remained idle while the other caulked his side of the joint.

The men rolling lead wool worked fast enough only to keep the caulkers supplied and stopped whenever there was no caulking going on. As a matter of fact, one able bodied boy could have rolled in a day enough wool to keep the gang supplied for a week. Then the yarning was being done by hand, making the cost of yarning a joint actually greater than that of caulking it.

It was quite apparent that the whole proposition was one of system. Pneumatic caulking is much quicker and easier than hand work. Keep the caulkers busy all the time with their work laid out intelligently in advance; have the tools, yarn and lead always at hand so that it is unnecessary for a man to leave the trench and the result will be a considerable saving both in money and time.

As a result of this investigation, the force was reorganized according to the following scheme:— A foreman who was not "one of the gang" was placed in entire charge of the caulking and given to understand that his job depended on his ability to push the men and reduce the time per joint. He was furnished with blank reports, (see Figure 10) and instructed to forward one properly filled out each night to the main office. This report served two purposes:— it allowed the work to be followed very closely by the interested parties at headquarters, and also caused the men themselves to brace up, knowing that their individual results were being watched. We were also able to keep better informed about the com-

Fig. 10.—Daily Report—Compressed Air Caulking.

48th-134th St. Line. Type of compressor, Ingersoll-Rand-Abenaque. Type of hammers, Ingersoll-Rand.
Weather, fair, morning; showers, afternoon. Date, Aug. 9, 1910.

Name	Grade	Rate	Total hours worked	No. of joints caulked	Joint No.	Time yarning	Time caulking	Total time for joint	Weight of yarn pounds	Weight of lead pounds	Time on work other than compressed air caulking—State nature of work	Compressor				Hammers			Remarks
												Total hours running	Gals. gasoline used	Qts. lub. oil used	Repairs	Total No. on hand	No. in use	Repairs	
E. Gury	Caulker	$3 00	10	2	1	50′	2:45	3:35	13½	157	All	7:10	8	1	None	8	7	None	Delayed
D. Mahoney ...	Caulker	3.00	10		2	50′	2:55	3:45	14¼	160	hands								1 hr.
T. Dillon	Caulker	3.00	10	2	1	50′	2:55	3:45	14¼	158	made								50 min.
D. Cregan	Caulker	3.00	10		2	45′	2:50	3:35	14	158	300′								waiting
C. Gruber	Caulker	3.00	10	2	1	45′	2:45	3:30	13	143	shift								for joint
H. Daniels.....	Caulker	3.00	10		2	45′	2:45	3:30	13¾	155	with								holes to
B. Costello.....	Caulker	3.00	10	2	1	45′	2:50	3:35	14¼	166	com-								be dug.
F. Hogan.. ..	Caulker	3.00	10		2	50′	2:50	3:40	14	168	pressor								Also
T. Skelley	Foreman caulker	3.00	10																delayed
S. Salt	Comp. engineer	3.00	10																½ hour b pay-
M.Cunningham	Tool man	1.90	10																master's
Labor rolling lead wool....		2.56																	wagon
Total.....		$34.46		8															

Total labor and compressor cost, (compressed air caulking only) $35.36. Total number of joints, (compressed air caulking only) 8. Average cost per joint, $4 42 + depreciation, .30, = $4.72. Hand, $7.11. Saving, $2.39. or 33%.

G. A. SHERRON, Field Engineer.

pressors and tools, and to compare the result obtained with different types. The report was, of course, checked up by the Field Engineer before being turned in, and he was able to tell at a glance whether any time was being wasted.

It was decided at this time to yarn all joints by air. This proved quite successful, the yarning time being cut from two hours 15 minutes to as low as 30 minutes. The lead rolling force was cut to one man who was sent away from the work to the storeroom and kept busy whether the caulkers were working or not. Still another improvement was made by providing the gang with a laborer acting as a tool man. Quite a lot of time had formerly been wasted by the men in running around looking for tools. The average Irish caulker when looking for anything, with the possible exception of a fight, has about as hard a time finding it as our well known friend Diogenes. When tools were needed it was up to the tool man to provide them,—enough spare hammers being kept in reserve to immediately replace any needing repairs or adjustment. The caulkers were under no circumstances allowed to leave the trench during working hours. With these changes, the gang made a fresh start and the results shown by the next cost report turned in were more than gratifying.

The conditions under which the work covered by this report was done were unusually severe. The joints were all in a loose rock trench running through very low ground, the presence of salt water making it impossible to caulk at high tide. The cost per joint would naturally be higher under these conditions, as a certain amount of time is lost in shifting the whole gang to another part of the work when driven out by the water. The greater speed possible with pneumatic caulking was especially valuable to us here, as we were able to complete a whole joint between tides instead of having to leave it when partly completed and then come back the next day and clean out the mud before being able to continue.

Following is an abstract from the cost report:

Total number of joints yarned and caulked	39
All labor charges, (caulkers, foreman, toolman, leadman and compressor engineer)	$189.46
Gasoline, oil and repairs	5.44
Total cost—39 joints	$194.90
Cost per joint	5.00
Plus depreciation on plant—per joint	0.30
Total cost per joint	$5.30

This cost would undoubtedly have been lower still, but for the fact that half of our hammers had been sent to the Ingersoll Rand Repair Shop to be fitted with lock nuts and washers, as recommended by their expert.

It would not be quite fair to compare this cost per joint with the cost of hand caulking in a dry trench. If it requires ten hours for two men to yarn and caulk a 48 in. joint under normal couditions, it would certainly take twelve hours to do the same amount of work in a tide water trench. On this basis, the cost per joint would have been as follows:

2 caulkers—12 hours each @ 30 cts. per hr.	$7.20
Labor rolling lead—(per joint)	0.30
Foreman caulker—(per joint)	0.40
Total cost per joint—hand caulking	$7.90

There was, therefore, a saving of $2.60 per joint, or about 33 per cent.

The daily cost reports to date on this particular line, have checked this figure very closely—the saving of air over hand work averaging about 30 per cent.

On the line in question, there were roughly 750 joints. Taking the average cost per hand caulked joint (see page 9) as $7.11, the total cost of hand caulking would have been—$5,332.50. The total saving, using air tools, would, therefore,

be very close to $1,600.00 so that the outfit will practically pay for itself in the first season's work.

These figures are quite conservative. While the weather conditions were ideal there was quite a little time lost in shifting the compressor around, as pipe was being laid at two different points on the line and it was never possible to have a straight run to caulk of more than 300 feet. There were also days when there was no pipe ready for caulking. When this condition arose, the foreman and compressor engineer overhauled and cleaned the compressor and the air hammers, and the caulkers were put to work as laborers.

The ability to caulk several joints quickly proved of great value on this line in allowing some rather bad street intersections to be finished up and back-filled with the least possible delay. While the money value of such a saving would be rather hard to compute, it must be quite an item when we consider the maintenance of intersecting pipes and sewers, sheeting, shoring, temporary bridges, night and day watchmen, and the ever present possibility of accidents to vehicles and pedestrians while the street is open.

We were quite pleased to find that we were able to get from 10 to 15 per cent. more lead wool into these joints by means of the pneumatic tools than we had previously been able to get by hand. This proved conclusively that pneumatic caulking gives a more compact, and consequently a more nearly gas-tight joint than the old method.

The second compressor to arrive was the National Brake and Electric Outfit (see Fig. 3);—this was placed on a 36 in. line and after spending some time breaking in the caulkers, a gang was organized along the ideas described above. The same difficulties were experienced at first. A few tools were broken, the compressor stopped unexpectedly a few times, but finally things were licked into shape and we began to get results. The compressor on this line was larger than that on the 48 in., and it gave excellent service drilling rock, at the same time running enough hammers to keep all the caulkers

busy. At the present writing, there has been more rock drilling on this line than caulking, so there is still room for improvement in the cost figures. This will, undoubtedly, come with practice and systematization of the work.

Taking an average daily report from this line, the cost per joint figures as follows:—

[1]Total labor and compressor cost	$17.75
No joints yarned and caulked	9⅜
Cost per joint	1.85
Plus depreciation on outfit, per joint	0.30
Total cost per joint	$2.15

Also 41 ft. of 1 in. hole drilled at a cost of 21 cents per foot.

The cost of hand caulking per joint would have been as follows:— To do nine 36 in. joints in a day would take a gang of ten hand caulkers at an average rate of $2.75 per day. A pair of good hand caulkers can do two joints in a ten hour day, but the average will be a little less than that. No time for a foreman caulker is charged in as the pipe foreman on this line looks after the caulking and for a given number of joints his time would be the same for both compressed air and hand work:

10 caulkers @ $2.75	$27.50
Labor rolling lead	1.00
Total cost—nine joints	$28.50
Cost per joint	$3.17

This gives a saving per joint in favor of compressed air caulking of $1.02, or about 32 per cent.—very close to the average percentage of saving on the 48 in. work.

It will undoubtedly be possible to cut the cost, per joint, on the air work still further when it is not necessary to drill rock and caulk at the same time. The drills use a large

[1] On this work we were able to obtain caulkers at an average of $2.50 per day, as against $3.00 on the 48 in. Line.

amount of air and make it impossible to run more than six caulking hammers. The compressor can easily run double that number and the fixed charge per joint (which is a fair sized item) could, therefore, be cut in half. The caulkers will also in time become more expert, thus increasing the number of joints per day. The working conditions on this line were not as severe as on the 48 in. previously described, but when we stop to consider that more than half the caulkers were absolutely green (not even having a hand caulker's experience), the results are very encouraging. Caulkers are not always numerous in New York City and if it is possible to break in absolutely green men as quickly and satisfactorily as this, our troubles are ended in this direction.

The compressor outfit furnished by the National Brake and Electric Company proved quite satisfactory. A $2.00 per day laborer who had never seen a gasoline engine before was able to run it without any trouble, and the repairs cost next to nothing. The only possible objection to this outfit was the inability to move it readily on account of its weight. We expect to purchase a smaller outfit of this type of half the air capacity and about one-third of the weight to be used for caulking. The larger compressor will then be used exclusively for rock drilling where it is not necessary to make as many shifts.

It might be well to add here, that a compressor need not be looked upon as a dead loss during the Winter months, or when no outside work is in progress. There are many ways in which compressor air tools can be used to advantage on repair jobs around the Works, and the testing of long stretches of main becomes an easy matter with a ready supply of air at any required pressure always at hand.

We were so well pleased with the results on the 48 in. and 36 in. lines that a third compressor outfit of the Ingersoll Rand-Abenaque Type was ordered for use on the 30 in. work. This compressor, unfortunately, arrived a little behind schedule and we were only able to use it for two weeks when the work

was temporarily suspended on account of a delayed shipment of pipe. The results obtained in these two weeks were quite promising though, and with very little practice a pair of caulkers would be able to do five joints per day, as against two by hand. This would give a saving of about 30 per cent. and possibly better, as the working conditions here are ideal. The caulking gang was organized on the same basis as that described for the 48 in. line, and past experience enabled us to eliminate most of the troublesome features.

The average air pressure carried on the receiver gauge was about seventy pounds. This gave from fifty to sixty-five pounds pressure at the tool and was found quite sufficient. The compressors were all fitted with unloaders, which when set for any given pressure, regulated the air supply automatically.

From the results obtained on these three lines, it would certainly seem that pneumatic caulking of lead wool joints gives better and quicker work with a considerable saving in cost. The caulkers themselves are better satisfied as their work is much easier and it takes considerably less time to break in a man as a pneumatic caulker than it does to get him in shape to swing a 3½ lb. hammer for ten hours. As I have stated before, the supply of caulkers in New York City is not always equal to the demand.

THE PRESIDENT: Gentlemen, there are three written discussions on Mr. Simpson's paper. As some of the authors of these are not present Mr. Earnshaw will read the discussions.

MR. EARNSHAW: This is a discussion by Mr. Jacob D. Von Maur, of St. Louis.

I have read Mr. Simpson's paper with a great deal of interest.

A number of years ago we experimented in St. Louis with pneumatic caulking in laying our 24 in. high-pressure lines, using cast lead for making the joints. We did not find the result satisfactory either from a cost standpoint, or the

character of the work obtained. The reasons were substantially as stated in Mr. Simpson's paper.

The best results with hand-caulking and using cast lead are obtained by using light sledge hammers for caulking instead of the ordinary caulker's hammer. The work is not only better, but the joint is completed in considerably less time.

With the use of lead wool, however, the proposition is entirely changed. Here we have a material which, from its nature, involves a great deal of labor to caulk the joint satisfactorily. The hand-labor cost is increased very greatly, and Mr. Simpson has demonstrated that where there is sufficient work to warrant the purchase of a plant this labor can be done at a reasonable expense, and undoubtedly gives a very much tighter joint than could possibly be obtained by either cast lead or cement.

I would like to ask Mr. Simpson under what gas pressure these cast iron mains are tested and operated, and whether any of the joints leaked on the test made after the joints were caulked, also have any of the joints leaked in actual operation? It is, of course, understood that these joints are very much tighter and remain so, than where the joints are made with cast lead; otherwise there would have been no object in going to the greater cost of using the lead wool.

In St. Louis all our mains are laid using Portland cement for joint-caulking purposes. For joints 12 in. and under there is absolutely no question as to the value of cement for this purpose with 5 pounds operating pressure.

The idea that mains laid with all cement joints have a tendency to break has not been borne out in our practice, as we have not had a single main broken from this cause out of a total of several hundred miles.

We also laid a 30 in. cast iron main with cement joints, which is operated under low-pressure, and although this main has been in use for several years we have never had any leaking joints on it, but with the 24 in. mains, which are operated under 5 pounds pressure, we have had considerable difficulty, yet I am satisfied that these mains can be laid, using cement

for the joints, which will remain absolutely tight. My reason for so believing is the fact that we have many long stretches where no leaks have occurred. If it is possible to lay one stretch of main which will remain tight it would seem that if other mains are laid in precisely the same manner, and under the same conditions, that they should also remain tight.

Unfortunately we stopped using Dyckerhoff cement and substituted a local Portland cement, which is one of the best in the market for ordinary purposes, but yet which gave us considerable trouble when used for joints.

The great trouble with using cement is the fact that it may test very well when laid, but may leak after six months or a year. Most of our joints were absolutely tight at 30 pounds pressure twenty-four hours after they were laid, yet these same joints leaked after being in the ground six months. This illustrates the danger of experimenting on a large scale with cement, especially in a large city, where the cost of repairing joints is very great.

The difference in cost of using cement and lead wool, however, is so great that it would seem that the large gas companies should carry on the work of experimentation until it is definitely decided at what size main the use of cement is no longer economical. But where it is decided to use lead wool on a large scale the caulking should certainly be done with pneumatic tools, as otherwise the labor is well-nigh prohibitive.

All gas men having to lay large size mains will certainly appreciate Mr. Simpson's paper on this practical question, and the full details given will be a guide for any one planning future work.

Mr. Earnshaw then read a written discussion by Mr. A. H. Hall, as follows:

Mr. Simpson has prepared a paper which will prove of value to every member of the Institute, who is connected with the street main department of his company. The only form of discussion which suggests itself to me is one which lays emphasis on the difficulties encountered, so that they may be avoided in future operations.

In his first paragraph Mr. Simpson gives two main reasons for the failure of the earlier experiments of the Consolidated Gas Co. Neither of these to my mind gives the real reason. The first of these, the well-known fact that cast lead cannot be compressed by caulking for more than ½ in. to ¾ in. back from the face of the joint, applies with equal force to hand work. The second reason is also fallacious as the time could have been reduced had the proper tools been used, in practically the same proportion with cast lead joints, as with those in which lead wool is the medium. In the Central Union Gas Co. we first started to caulk with pneumatic hammers, in 1904. The Company had purchased a portable gas engine air compressor outfit for use in rock drilling, the argument being that a gas engine was a better advertisement for a gas company than a steam boiler. This plant was first used on a 24 in. line in which cast lead was used for the joint making material. After the outfit had proved a success at rock drilling, we started to experiment with it for caulking. We asked the hammer manufacture to give us pneumatic tools which would strike a blow equal to that struck by a man using a 3½ lb. hammer, and made our caulking tools with the same width and depth of face as we had been using in hand work. This trial was an absolute failure, firstly—because the hammer was too heavy to be handled in the trench, secondly—because the very rapid movement of the piston made it impossible to deliver less than 7 or 8 blows of 3½ lbs. force at each setting of the tool against the face of the joint, and thirdly—the caulker didn't want it to work. In our next trial, we used a hammer of about half the size and increased the width of the face of the tool to about 2½ in. The labor question we solved by giving the hammer to a bright Italian laborer with the promise of an increase from $1.50 to $1.75 per day "if he made it work." After a little practice this man turned out very satisfactory work, and did twice as many joints per day as the hand caulkers.

Mr. Simpson has been rather unfair to the pneumatic system in his method of charging depreciation. If 30 cents per joint

is the correct figure when the outfit is being operated at the rate of 19 joints in 3 days or 6⅓ joints per day, it is manifestly too high, when 8 joints, or 9⅗ joints, are finished per day. This is particularly true of the latter case where the machine is credited with rock work to the value of (41 ft. × 0.21c.)—$8.61 on the same day. The estimated figures for hand labor also seems too low if worked out on the same assumptions as were used in the case of the 48 in. work. In the latter case it was assumed that two caulkers could finish one 48 in. joint, per day of 10 hours. Working at the same rate they should finish one 36 in. joint in ¾ of a day (7½ hours) or each 36 in. joint would require 15 hours labor. On this basis the estimated cost would work out as follows: the caulkers being charged at 30 cents for comparative purposes:—

9 joints at 15 hours per joint—135 at 30 cents ..	$40.50
Labor rolling lead	1.00
	$41.50
Cost per joint	$ 4.61

which would show a saving of $2.46 per joint or about 53 per cent.

There seems to me one point to which Mr. Simpson might have drawn greater attention, and in the light of the modern humane practice of bettering laboring conditions wherever possible, it is of undoubted importance. In caulking any kind of a lead joint in a trench by hand, the men wielding the hammers work under extremely hard conditions. The positions in which they must place themselves in order to properly address their work are almost always cramped and uncomfortable. I have frequently seen caulkers lying on the pipe to caulk the under side of a joint when the iron was so hot from exposure to the sun as to be almost too warm for me to bear my hand on. In caulking sizes larger than 12 in. it is necessary for two men to work at the under side of the joint. They lie on their backs in the bell hole, and one man holds the

caulking tool against the lead while his mate strikes it with his hammer. It is very difficult for a man who is not ambidextrous to caulk both sides of a large joint. All these conditions make the work of a hand caulker very trying, and although the pneumatic hammer does not take him out of the trench, it does help him to do his work with a smaller expenditure of muscular effort.

THE PRESIDENT: Is Mr. Walton Forstall present?

MR. WALTON FORSTAL: I was not sure that I would be here, so I put my remarks in writing. Some of the points have been made by some of the other members in their discussion.

I am glad to be asked to discuss this paper of Mr. Simpson's, first, because joint making is one of the most important distribution problems; and second, because I had the pleasure this summer, under Mr. Simpson's guidance, of seeing pneumatic caulking of 48 in. joints.

Any one who has had to do with large mains under expensive paving, realizes that a method of joint making, which produces not only tight joints, but joints that *stay* tight, may greatly exceed in first cost, a cheaper method, and yet in the long run prove more economical than the cheaper method, if the latter results in many leaky joints year by year. This undoubtedly is particularly true where the main in question is a 48 in., and the city, New York. Therefore, I consider that without the actual saving Mr. Simpson has shown for pneumatic caulking over hand caulking, it would still have strong claims for consideration under his conditions. I say this because I believe that pneumatic caulking renders much more certain the uniform and proper compression of the lead wool. Right here, however, I wish to say that my experience with lead wool has been very limited. Such as it is, it has left me with the impression that when using lead wool, more attention must be paid to the caulker and his work, than is true of cast lead joints. This for the reason that the only justification for the extra first cost of a lead wool joint over one of cast lead, lies in the fact apparently pretty well demon-

strated, that it is possible for this extra first cost to secure a joint that stays tight. This permanent tightness results only if the lead wool is properly caulked, in which case a joint of about the same density as the ½ in. or ¾ in. of the compressed layer of cast lead, is secured for the *whole* depth of the lead wool joint.

This subject does not appeal to the small gas works, but the large cities should keep in touch with this matter, as further experience may show that pneumatic caulking pays in sizes as small as 20 in. The Technical Committee should obtain next year a further contribution from Mr. Simpson, giving another year's experience. If a record is available, showing the percentage of leaking joints found each year, to the total joints in service, divided as between cast lead, lead wool hand caulking, and lead pneumatic caulking, these facts, after ten years or so, would be very valuable to all companies laying large pipe. In the meantime, Mr. Simpson is deserving of our thanks for having blazed a new trial and brought it to our notice.

I have already stated that Philadelphia has done little with lead wool. It has, however, had a larger experience with cement joints than any other city, and what follows is given as being of value to Institute members.

The practice of using cement instead of lead for small pipe was begun in 1900, and in 1902, extended to all sizes. From the beginning, a careful record was kept of all leaks found in cement joints, because it was thought important to know *exactly* what success, or failure, was met with. The results to the end of 1909 are as follows:

Size of pipe	Feet laid	Leaky joints
4 in.	105,124	7
6 in.	1,333,953	25
8 in.	49,891	3
12 in.	59,967	19
16 in.	33,687	54
20 in.	51,833	99
30 in.	20,521	332

The record is entirely satisfactory, except for the 30 in.

Half of this pipe was laid by "A" district organization, and half by "B." On the "A" half, 310 leaks have been found, and on the "B" half only 22. This being the case, it seems as if the "A" caulkers did not possess the knack of those employed in "B" district. At any rate as long as 10,000 feet have only shown 22 leaks in four to eight years, we do not believe that it is impossible to make a 30 in. cement joint that will stay tight. We have not been able to arrive at any definite opinion why there have been so many failures in "A" district. Ground vibration, due to railroad trains, and settlement, due to shifting gravel, are two causes that may have had some effect, but, personally, I believe that the fault lay in the "man behind the hammer," and that "B" district obtained a stronger adhesion between cement and iron than did "A" district. In almost every case, the crack was a very fine one. It showed no partiality for any particular portion of the circumference, and the cement separated from the spigot as often as from the bell.

In order to eliminate settling from the causes of joint leaks, two years ago it was decided to use concrete piers, two under each length, when laying 1,200 feet of 36 in. pipes. So satisfactory was the experiment that this spring, the same support was given to 3,000 feet of 30 in. Data from these lines will be interesting after some years have gone by.

Of course, the most satisfactory feature of cement joints, lies in their cheapness. In round figures, Philadelphia must have saved $100,000 by the substitution of cement for cast lead.

The President: Are there any other remarks on this lead wool caulking? If not, we will call upon Mr. Simpson to close the paper.

Mr. C. C. Simpson, Jr.: There is nothing further I care to say in this connection except with reference to the shape of the caulking tools in Fig. 1. We tried all sizes and shapes of every size and finally adopted this style. This tool is about a square inch of metal. We found it made a good sized test. We get plenty of pressure from the hammer and just do the

caulking so much quicker. If we had a little tool like a hand tool, we just punch a hole in the lead. This table of the different sizes of tools is what we are using at present, but you practically have to evolve your own tools for the different sizes of pipes, depending on the pipe you use and the amount of lead space you have. In regard to the tests on this line, question of leakage, I would say that the line is not yet completed, so we have not made any tests of any kind. It is not our practice to make pressure tests. But I would say that in that territory there has been a thirty inch line laid about two or three miles long. It has been in service three years. The lead wool is hand caulked and there has not been a single leak on it. Now if we get a better joint with air than we do by hand, we ought to have better than no leaks in the 48 inch line.

Mr. Earnshaw: Mr. Simpson did not answer the question, which was of interest to me, and that was the operating pressure of this main and the pressure under which it would be tested. If he could give us some definite information on that point I think we should be glad to hear it.

Mr. C. C. Simpson, Jr.: I think I stated that is has not been our practice to make pressure tests on mains, if that answers the question, and the operating pressure would not be more than half a pound. It it a low pressure line.

Mr. Earnshaw: What is the operating pressure on this 30 inch main?

Mr. C. C. Simpson, Jr.: About two and a half inches. They are all low pressure lines.

The President: If there is no objection we will pass a vote of thanks to Mr. Simpson for his paper.

A vote of thanks to Mr. Simpson for his paper was carried.

Mr. C. C. Simpson, Sr.: I have proved conclusively a great many years ago that I can take a cast iron main of any size, whether four, six, thirty, thirty-six, or forty-eight inches in diameter and have a caulker pass his chisel around that joint and I could test that main up to five pounds and show tight, but it would only show tight about a week. That to

my mind shows the fallacy of any test of a large main being any good when it is made immediately after the main is laid. The trouble comes, not from the caulking of the joint—the joint is nearly always tight at starting— but with a large size pipe the least settling upsets the caulk and the joint commences to leak.

THE PRESIDENT: The next paper is

ACCURACY OF CONSUMERS' METERS.

MR. W. A. CASTOR.

Mr. Castor then read his paper as follows:

THE ACCURACY OF CONSUMERS' METERS.

From that time in the early days of gas making when it was discovered that the business could only be made profitable by selling the product through meters, the problem ever confronting the gas company and the meter maker has been to obtain a meter that would register correctly the volume of gas delivered to the consumer. This point has been obscured at times by a discussion of the relative merits of different types, or of questions of speed and capacity, but to the clear thinking manager the question of accuracy of registration commands his best consideration.

No gas company manufactures its own meters, but buys them from a meter maker, who is forced by competition to keep up the high standard of constructive detail now demanded by the larger gas companies, with the idea constantly in view of maintaining and increasing, if possible, the reliability or dependability of the meter as an accurate measuring device over long periods of service. The meter manufacturer, therefore, is very much alive to the situation and must realize that in the long run the best make of meter, and by this is meant particularly the ability of the meter to hold its correct proof in active service, will be the make demanded by the gas company which keeps careful watch over the meters through which their consumers are supplied. Meter manufacturers as a whole exercise every possible precaution, and welcome every suggestion which in any way

tends to insure the proof of meters remaining correct or within very small limits of error.

It cannot be denied, however, that the meter makers have done their part in furnishing meters to the gas companies that are honestly and scientifically made, and which to a very remarkable degree possess the essential property of accuracy under the trying conditions of use in actual service.

The accuracy of the consumers' meter may be said to depend upon its ability to show upon the meter index dial a correct registration of the volume of gas or air passing through the meter. Newbigging lays down as the second of his golden rules for gas managers,—"Keep up the efficiency of the meters." In practice this efficiency is determined by a comparison of the registration of the meter with the reading of a scale attached to a correctly calibrated volumetric measuring device, indicating the volume of gas or air passing from this measuring device through the meter. A similar reading of both indicators shows a meter efficiency of 100 per cent., all of the gas or air passing through the meter having been correctly indicated by the proving head pointer, or test hand. If the indicated efficiency of the meter is more than 100 per cent. the meter is fast, more gas being registered by the index than has actually passed through the meter; while on the other hand, if the quantity registered by the meter index is less than indicated by the scale on the measuring device, the meter is slow.

Gas meters are usually set in cellars, but often of necessity must be set under porches, out of doors, in damp locations, or in places subject to sudden temperature changes; in fact in almost every conceivable place and under almost every conceivable condition of variation in temperature and moisture. Moreover, when once set the meter generally remains for a term of years unattended except for the periodical visit of the meter reader. Almost any other known piece of mechanism in use receives more attention and care than does a gas meter—boilers are washed out, shafting lubricated, and pumps and engines overhauled at frequent intervals. The

gas meter, however, receives almost no attention ordinarily, unless something develops necessitating a visit of the complaint man or fitter to the consumers' premises. The meter must be ready for business day in and day out; year in and year out, and consequently must be constructed in all its parts so as to possess a high degree of dependability:—for dependability and accuracy of registration in meters go hand in hand.

Meters like other mechanical devices require attention and overhauling after certain periods of service. These periods of service should be determined by some definite means, and not guessed at; otherwise the gas company will be put to unnecessary expense in changing the meter before necessity demands, or on the other hand suffer losses due to the increased *slow net error* of registration of meters allowed to remain in service for too long a period of time.

As volumes of gas or air cannot be handled like liquids or solids, special means must be provided to effect the correct measurement of the gas or air which is passed through the meter for the purpose of determining the accuracy with which the meter registering mechanism, usually called the index, will register the same. This being a fact it is necessary to first obtain a cubic foot measure capable of measuring and delivering without loss, one cubic foot of gas or air. A measuring device of this description is known as a cubic foot bottle, and should be so constructed and calibrated as to deliver a cubic foot, which is the unit of measure, or the volume of 62.2901 pounds (avoirdupois) of air-free distilled water at 60° F., weighed in air of the same temperature and at a pressure of 760 mm. (29.92 inches). It is usually so constructed with sight tubes and indicators that the one cubic foot of air or gas contained in the body of the bottle and in the sight tubes between the indicators may be displaced by the water entering at the level of the bottom indicator and rising to that of the top indicator.

All cubic foot bottles should be tested, badged and certified to by the Bureau of Standards, Department of Commerce

and Labor, at Washington, D. C., and all indicators and adjustment screws soldered in position by the men conducting the test, in order that the final adjustment cannot be altered intentionally or otherwise.

Upon the return of the certified bottle from Washington, it should be carefully unpacked and mounted securely in a well protected location in a room the temperature of which may be readily regulated and in which there is an abundance of daylight. Any damage to, or tampering with the standard cubic foot bottle warrants its immediate return to the Bureau of Standards for re-test and adjustment as no chances should be taken with the primary standard by which our meter provers are calibrated and re-tested from time to time.

The cost and construction of the cubic foot bottle, the difficulty experienced in protecting same from possible damage, and the care necessary in operating, renders the use of the bottle for the purpose of testing the meters for accuracy of registration impracticable.

For this purpose a more convenient piece of apparatus, called a meter prover, is provided, consisting of a cylindrical holder or bell closed at the top and sealed at the bottom by water in which it is free to move up or down, similar in action to a single lift gas holder. The bell of the meter prover is balanced by means of a cycloid and weight to compensate for the buoyant effect of the water upon same as it is immersed or withdrawn, thus insuring a constant uniform pressure being exerted by the bell upon the contained gas or air.

The general construction and operation of the meter prover now in general use for testing the accuracy of registration of consumers' meters is so well known that no detailed description need be given. The method of calibrating or marking the scale attached to the prover bell, however, is not so well known and consequently calls for a brief description. All provers are calibrated by means of the standard cubic foot bottle, and each cubic foot is marked on the prover scale as determined by the rise or fall of the bell as each succes-

sive cubic foot of air is either forced into or withdrawn from the bell by the operation of the cubic foot bottle.

The practice of further subdividing each cubic foot division of the scale was formerly to divide the scale mathematically for a short distance above and below the 2, 4, 5, 6 and 10, cubic foot marks into 1/100ths of the distance from zero to each of the above mentioned cubic foot markings on the scale, the idea being to read the error of the prover direct from the scale, considering the meter as passing 100 parts and the prover as passing the number of parts indicated by the scale. A prover scale reading of 99 (99/100ths of the volume registered by the meter) was considered as showing the meter to be one per cent. fast, or, on the other hand, as being one per cent. slow if the reading was 101. As a matter of fact the meter was in error more than one per cent. fast and less than one per cent. slow, the indicated and actual percentages, however, being close enough within the small limits of error to enable the direct reading of error from the prover scale to be employed when adjusting meters on the check and open test. Most prover scales are now divided into tenths of each cubic foot, and for a short distance above and below each cubic foot mark each tenth is further divided into fifths so that a reading of 1/50th cubic foot may be read direct from the scale, and with a certain degree of accuracy a reading of 1/100ths of a cubic foot can be obtained.

Having obtained the reading of the prover scale in feet and 1/100ths of a foot, the percentage of this known volume the meters register above or below this volume is determined by reference to a percentage of error table provided for the purpose.

The temperature of the air in the room in which the prover is to be tested and calibrated, the temperature of the water in the cubic foot bottle and in the prover tank should be the same during the operation, and in addition the air in the room should be thoroughly saturated with water vapor in order to obtain accurate results. Separate thermometers should be used for air and for water and same should show similar

readings when tested in comparison with a seasoned thermometer.

Meter provers should be tested at least once each year, a small portable one cubic foot prover being successfully used for the purpose in place of the slow acting, cumbersome standard cubic foot bottle. The cubic foot prover should be carefully checked against the standard cubic foot bottle previous to starting a series of tests, all precautions as to temperature and saturation being carefully observed during every test.

Every gas company should possess one or more meter provers and the necessary connections, test caps and thermometers. Separate thermometers should be provided for taking water temperatures and for taking the temperature of air in the proving room. When tested under similar conditions, the thermometers used with any prover or pair of provers should not differ more than one degree Fahr. the range of temperatures covered by the test being from 60° to 100° F.

Meter provers should be so set that the bell will rise and fall vertically and not be subjected to any binds against the guide rods. Where the floor is cold, the tank should be raised off same by means of feet provided for the purpose or be placed upon a low table. Care should be exercised to select a proving room where plenty of daylight is available as the prover scales are difficult to read correctly in other than a good light. Means should be provided for easily regulating and maintaining the temperature of the air in the proving room and of the water in the prover tank, as a variation of about five degrees in temperature between the two may result in an error of one per cent. in the proof of the meter. When a difference of two degrees between the air and water is shown, the temperature of the water in the prover tank should be changed to agree with the temperature of the air in the proving room. The prover tank should be connected with hot and cold water pipes or with a steam pipe and a cold water pipe, or with a cold water pipe and a submerged

electrical heater, for the purposes of readily changing the temperature of the contained water. Before taking a reading of the water temperature, at the time of making a change in same, the water should be stirred from the bottom of the tank by means of a long wooden paddle, in order to equalize the temperatures. The temperature of the air should not be suddenly changed by opening doors or windows or due to other causes, as the meters in the room waiting test, change their internal temperatures but slowly. The greatest importance should be placed upon the necessity of setting the prover in a position where it will not be subjected to any draught and where it will not receive the direct rays of the sun.

The only test for the degree of accuracy with which meters will register the passage of gas or air under different flows and pressures is that made by passing air or gas from a carefully calibrated prover through same.

The meter proving head pointer is allowed to make either one or two complete revolutions during a test for accuracy of registration and the whole number of cubic feet thus registered is compared with the cubic foot readings of the prover scale in order to determine the error of the meter.

In order that meters will register correctly under all conditions of flow, careful and accurate setting of the valves in relation to the positions of diaphragms is necessary at the time the meters are fitted up, or at any subsequent time when the relation existing between the diaphragms and the valves has been altered, as the result of flag arms being out of division or broken away from flag rod, flag broken away from flag rod, position of tangent changed, valve arms bent, etc. Experience has shown that it is not necessary to test meters under different rates of flow after each removal from service, as the difference in proof as shown by the tests (check and open) made under different rates of flow is so small in meters that do not plainly show evidence of trouble that it is a needless waste of time to make the proof tests at other than one rate of flow, preferably by check. Meters in which the valves are properly set will register with the

same degree of accuracy the passage of air or gas through same at different rates of flow, provided there is no leakage in any part of the meter. Any damage to the working parts of the meter which would materially effect the registration under varying rates of flow of gas or air through same would in nearly every case be manifested, and designated by some special terms, such as "works catch," or "won't pass gas." Internal or outside leaks would materially effect the proof of meters under each different rate of flow, but again, most of these leaks are detected or manifested during the pressure testing and small flame testing to which the meters are subjected upon removal, consequently there need be no concern from this standpoint. In practically every instance of inside leakage, the loss is sustained by the gas company, while outside leaks in the body of the meter result in the joint loss of both consumer and company but such outside leaks are quickly detected and remedied. As stated before, experience has shown that it is not necessary to prove meters under varying rates of flow through same, each time a meter is removed from service, and the question naturally arises as to what is the proper rate to use when making a proof test of a meter removed from service in order closely to reproduce the conditions as to flow under which the meter had been operating. If all meters of a given size operated constantly under the same condition as to flow, that condition would be adopted in making a proof test, but no such ideal condition exists in practice. To meet the practical requirements it is common to specify that the test of accuracy of registration shall be made when the meters are passing gas or air at a certain rate and the rate most commonly adopted is the number of cubic feet passing per hour, under a 15-tenths inlet pressure, which is equal to the rated capacity of the meter in number of lights multiplied by six. Same companies, however, take the average capacity under a 3-tenths loss in pressure, of meters of the same nominal size, as the rate at which the proof test should be made. Under the present conditions of supply and demand the last method may more nearly ap-

proximate the conditions which are met in actual service, for the reason that the average hourly demand has been greatly increased within the past few years, due to the general use of gas heating and cooking appliances in the consumers' homes. The advantage of using the larger capacity test cap on the meter outlet screw corresponding to a 3-tenths loss in pressure of the gas in passing through the meter, is the reduction in the length of time required in making the proof or check test as it is commonly called. The same proof, however, will be obtained at both rates if the valves are properly divided, and conditions inside of the meter do not change and no leakage exists.

The pressure thrown by the prover used in making the check test is usually 15-tenths inches of water column, the check caps furnished by the meter makers being reamed and stamped for the stated capacities under a 15-tenths meter inlet pressure.

The test accepted by all gas companies and by the several public service State Commissions as the proof of the accuracy of the meter is the check or restricted rate test. This test is made by passing gas or air from a meter prover through the meter under test, all precautions as to temperatures, tightness of prover and of prover connections being carefully observed. The object of this test is to determine with what degree of accuracy the test hand of the meter index will indicate the volume of gas actually passed through the meter during the test. The actual volume passed is shown by the prover scale, and unless the test hand indicates a like volume the meter registers in error, being fast if the test hand indicates more than the prover scale reading and slow if indicating less.

In order to determine the error in registration it is necessary to calculate same in the case of a fast meter by finding what percentage of the gas or air in excess of the known volume passed is actually indicated by the test hand of the meter. An illustration of this operation will no doubt make it clearly understood;—the meter under test shows by the

test hand as having passed two cubic feet of gas or air, while the prover scale shows that only 1.95 cubic feet actually passed. The difference between the indicated volume (2.00) and the actual volume passed (1.95) is 0.05 cubic foot, and the percentage 0.05 is of 1.95 is 2.56, or expressed in another form:

$$\frac{(2.00-1.95) \times 100}{1.95} = 2.56 \text{ per cent fast.}$$

The practice of reading the percentage of error direct from the prover scale should be discouraged, as such readings give only close approximate results for small errors, and decidedly incorrect results when the difference between test hand reading and prover scale reading is great. Taking the conditions stated in the above example and attempting to use the prover scale direct to obtain the error, we find that the meter recorded 2 cubic feet passed, and the prover only 1.95 cubic feet or 97.5 per cent. of the gas registered by the meter. It is obvious that it would be wrong to say that in this case the meter is 2.5 per cent. fast, for the 2.00 cubic feet indicated by the meter is not the quantity actually passed and consequently cannot serve as the volume of which we are to obtain the percentage of error in meter registration.

These conditions can be more clearly shown by assuming greater differences between meter and prover readings.

Meter reading	Prover reading
2.00 cu. ft.	1.00 cu. ft.

$$\frac{(2.00-1.00) \times 100}{1.00} = 100 \text{ per cent.}$$

In this case the meter is 100 per cent. fast for the reason that the test hand registered twice the known volume actually passing through the meter.

Meter reading	Prover reading
2.00 cu. ft.	1.00 cu. ft.

$$\frac{(2.00-1.00) \times 100}{2.00} = 50 \text{ per cent.}$$

In this case the meter is considered only 50 per cent. fast,

the prover scale reading but half that of the meter test hand, or in other words, the known volume passing through the meter is but 50 per cent. of the volume registered by the meter test hand, while it is self evident that the meter actually did register twice the known volume that passes through the same, and must therefore be 100 per cent. fast.

Take for example the following conditions:—

Meter reading	Prover reading
2.00 cu. ft.	2.50 cu. ft.

$$\frac{(2.5-2.0) \times 100}{2.5} = 20 \text{ per cent.}$$

The meter in this case would be 20 per cent. slow, the meter registering but $\frac{4}{5}$ of the gas passed.

The incorrect method of obtaining the error in meter registration is as follows:

$$\frac{(2.5-2.0) \times 100}{2.0} = 25 = 25 \text{ per cent.}$$

This explanation is called for, due to a recent publication covering the subject of meter testing, in which the author claimed that the method of determining directly from the prover scale readings, the percentage of error with which the meter registered the volume passed, was correct and preferable to the method of determining the error of registration on the basis of volume actually passing through the meter in comparison with the volume shown by the meter test hand, as having passed. This claim cannot be substantiated, as the above examples show.

The inaccuracy of meter index mechanisms is a question that has given rise to considerable thought and discussion lately, but from the consumers' and gas companies' standpoint there should be little apprehension of overcharge or loss from this source. Under the shop practice that prevails today, mechanisms are invariably made so as correctly to register the revolutions of the test hands, and the writer does not recall a single case of incorrect gearing in a gas meter index mechanism. It is true that a meter may be fitted up by a

careless fitter, with the wrong size of index, but this would be readily detected by the man who checked up the size of proving head in comparison with the volume of gas passed by the meter prover at the time of testing and adjusting the meter in question.

Instances of this kind are extremely rare, and any attempt to separately check up each index after same is mounted in the meter, would only show what the meter tester is now pretty certain to discover in his regular duties; therefore, it appears that no such inspection is necessary.

The pressure at which the gas is measured in the dry meter under ordinary practice does not appear to have any appreciable effect on the proof of the meter, and this is only to be expected, as under any pressure of the inlet gas, both sides of the diaphragm are subjected to almost the same pressure, the difference being the loss due to the passage of the gas through channels and valves, and in operating the working parts of the meter. Were it not for this slight difference in pressure between inside and outside of diaphragms or vice-versa, the meter would be deprived of its motive power and would not operate.

Most gas companies do—all gas companies should—test all new meters for accuracy of registration upon receipt of same, all new meters thereby being tested at least two or more times before same are placed in service.

Meters removed from service should be tested as quickly after removal as is consistent with the time required for the meter to acquire the temperature of the proving room, depending on the original difference in temperature between the two. In some instances one hour is sufficient time, while in others, five hours or even twelve hours are required. Too much emphasis cannot be placed on the importance of immediately capping or corking the pipes, or tubes, upon disconnecting the meter at the consumers' premises, as the action of the air entering the meter may cause a change in the proof, so that same when made in the shop would not correspond with the actual proof of the meter when passing gas in ser-

vice. For the same reason the first proof of a meter removed from service when either gas or air is used as the testing medium, should be considered as nearest the actual proof of the meter under active service conditions at time of removal just previous to the test. Previous to proving, about five revolutions of the tangent should be made by passing air or gas through the meter in order to purge same of accumulated vapors and to insure that the working parts are free to operate.

This first proof, even when using gas supplied through the piping exposed in the proving room is, in the vast majority of cases, somewhat faster than the proof of the meter when passing gas at the consumers' premises. The use of air from the proving room or of gas which has passed through any piping of a slightly higher temperature than that of the meter under test, will produce the same effect on the meter, causing successive proofs, in some cases up to 20 or more in number, to show progressively faster, the meters proving as much as 3 per cent. faster on the last proof than they did at the start.

The general practice throughout this country, with one or two exceptions, is to test both new and old meters with air. There apparently is no decided advantage gained by using gas for the purpose, for the reason that a dry gas will pick up the light oils and vapors in passing through a meter under test, thereby affecting the proof to the same extent as does air from the proving room. This question, no doubt, may seem unnecessarily brought forth, in view of the fact that no State or Municipal regulations specify whether gas or air is to be used in making the proof test of the meter; however, the fact should be constantly borne in mind that the first test with either gas or air, upon removal from service, is the nearest to the correct proof of the meter in service, and consequently any other proofs of a meter may not be accepted as correctly representing the conditions under which the meter worked. Experiments have been made with the use of air and gas, both saturated at the temperature of the meters under test, with the light vapor given off from con-

densation removed from other meters. The results obtained were very satisfactory, each successive proof remaining constant, showing that conditions of diaphragms and valves did not change as a result of the saturated air or gas passing through the meters under test.

The gas entering a consumers' meter, is, according to the season, and to the relation between ground temperature and cellar temperature, sometimes saturated with water and oil vapors, and sometimes it is not. This point is clearly explained by Mr. J. M. Rusby in his paper "Consumers' Meters, Causes of Variation in Proofs" read before this body in 1906. The accuracy of the meters therefore, varies somewhat with the seasons, but without injustice to the consumer, as these seasonal changes tend to neutralize each other. It is evident, however, that after a meter is removed from service and ready to be tested, the air or gas used in the test should be in such condition as to cause no change *during the test,* in the condition of the meter valves and diaphragms; therefore, a saturated air or gas should be used. This should be done whenever very accurate results are desired, corresponding to the proof of the meters in service, and when consecutive tests are made upon removal of the meter, and each test accepted as representing the conditions as to proof under which the meter passed gas in actual service. The air or gas used in making the test, may be thoroughly saturated by causing same to pass through a small saturation box placed close to the inlet to the prover.

The practice of introducing a considerable quantity of oil into the diaphragm compartments of the meter, and known as "dipping," appears to be growing. The writer can say from experience that dipping meters hold their proof on successive tests with air or gas, much better than do non-dipping meters, due no doubt to the diaphragms being saturated at all times with a less volatile oil than in most cases are the diaphragms of non-dipping meters.

The practice of making meters dipping has resulted in an increase in *net* error slow of the meters tested upon removal

from service. A glance at tabulated results of meter tests covering say a period of one year will readily show why this is so. Dipping meters as a class prove within smaller limits of error than do non-dipping meters, the general tendency, however, being to err on the slow side, the fast meters constituting a very small percentage of the total dipping meters tested. The average fast error is smaller for dipping than it is for non-dipping meters, as is also the average slow error; comparing dipping with non-dipping meters, of the total number tested, a smaller percentage tests fast, and a larger percentage tests slow, resulting in an increase in the *net* error slow. This result seems to be a step in the right direction, for admitting that the simple mechanism constituting a dry gas meter is liable to err, as is also the finer mechanism constituting a watch, or finer still, a human being, it is to be desired by every gas company that the error in meter registration show against the company, rather than against the consumer. The ideal condition would be to have all meters register absolutely correct under all the varying conditions to which they are subjected in service, but as this condition has not been attained as yet, despite the acknowledged correctness of principle of the present two diaphragm dry gas meter, and the constant endeavor being made to improve the constructive details of same, the next best thing is to wipe out or materially reduce the fast error and have all of the meters either correct or within very small limits of error on the slow side.

The increased slow *net* error of dipping meters should not cause any alarm among gas companies, for the reason that from present indications the increase will not exceed one per cent. over the slow net errors shown for non-dipping meters. While dipping meters as a class prove within smaller limits of error, the meters showing a fast error being greatly reduced in number, at the same time, those showing a slow error are greatly increased in number, the average error in each case being within smaller limits for dipping than for non-dipping meters.

The quality of gas and the temperature conditions are important factors affecting the proof of the meters in service. Meters which are required to pass coal gas are subjected to less variation than are meters through which pass a mixed gas, a water gas or an enriched oven gas.

The most important factor in producing a variation in proof, is the temperature changes to which meters are subjected, as shown by Mr. John M. Rusby's paper referred to above. With the possession of this knowledge it becomes the duty of those responsible for the setting of meters to select locations in which they will not be subjected to sudden changes in temperature or to great difference in temperature to that of the inlet gas.

The importance of exercising great care in adjusting meters to correct proof and the difficulty in maintaining this proof in service, should be apparent after reading the above statements. In the first place, slight errors are liable to be made in standardizing the cubic foot bottle. In the use of the cubic foot bottle great care must be exercised to have the water at the proper levels in the sight tubes, at the start and finish of any test; the thermometers used must agree under similar temperature conditions, similar temperatures of water and air must be maintained throughout the test, and the air of the room must be thoroughly saturated with water vapor to prevent change in volume of the air making a cubic foot test. Having exercised every precaution in marking the cubic foot capacities on a prover scale, a slight error may be easily made in marking the scale in a permanent manner and in laying off the sub-divisions of each cubic foot, and this together with the personal error in adjusting the scale to zero at the start and in reading same at the finish of a test, to say nothing of the effect of the temperature changes and of any unnoticed leakage, renders the operation of proving meters for accuracy of registration a very close approximation rather than an exact science. The meters that are adjusted to the greatest degree of accuracy permissible previous to being placed in service are, subject to wear of moving parts, deterioration of diaphragms,

effect of condensation and impurities in the gas, and the effect of temperature variations, all tending to affect the accuracy of registration.

These statements are made in order to show the necessity of allowing for variation in the proof of meters within small limits of error, either fast or slow, when attempting to define what constitutes a correct meter. The Railroad Commission of Wisconsin showed its appreciation of the difficulties experienced by the most exacting companies in proving meters and maintaining same within small limits of error by adopting the following:—"The accuracy of a gas meter may be defined in terms of the percentage with which it registers the actual volume of gas which passes through it. In the present state of the meter art it is impossible to secure a meter which is absolutely accurate, and which will remain accurate over a period of time. It is, therefore, necessary to define the term "accuracy" in such a way as to permit meters which fall within a small limit of error being considered as giving good service. The common method of testing the accuracy of a meter is to compare its reading with the volume of gas, as measured by the well-known "meter prover." It requires more than ordinary skill to measure the volume of gas with the meter prover so as to be certain of its value within one-half of one per cent., and ordinarily, in making the measurement, errors of observation or inaccuracy of the meter prover itself can amount to one per cent. Inasmuch as commercial meters cannot be made and adjusted to keep within this limit, a further allowance appears necessary, and for such allowance one per cent. seems to be a figure practically attainable."

The common practice in this country and in Europe is to consider a meter correct, which registers within two per cent. above or below the point of absolute correctness, as determined by the prover scale reading. On account of the difficulties experienced in endeavoring to attain accurate measurement and the impossibility of obtaining a perfect measuring device, meters that prove within this limit should for all practical purposes be considered as correct.

Meters, in order to be properly tested, should be carefully removed and taken to a thoroughly equipped room where all precautions necessary for making an accurate test may be taken. No attempt should be made to prove a meter on consumer's premises, as at the best this practice will produce very unsatisfactory results, and entail greater expense than would removal to a proving room. The attempt to prove one meter against another by passing gas or air through the meters connected in tandem cannot be too strongly objected to, for the reason that there is no positive assurance that the test meter so used will maintain its proof under the various conditions under which it must necessarily be used, and consequently, when the standard is subject to change, the test so made cannot be accepted as reliable. Complaint meters used in tandem with consumers' meters for the purpose of recording hourly consumptions of gas for a number of consecutive days, in order to demonstrate certain conditions of demand in order to take care of a complaint on the part of the consumer, should not be considered as a test of the accuracy of the consumer's meter so connected. One large gas company has taken the precaution to remove the indexes from their complaint meters in order that it will be impossible to prove one meter against the other, and has even gone farther by terming the complaint meter a complaint register, and always referring to same in the terms last mentioned. This does not necessarily mean that the complaint register or any special test meter that might be employed is not correct, but owing to the uncertainty of same, the difficulty of close readings of meter indexes, the uncertain light and difficulty encountered in maintaining constant temperatures, it is plainly evident to any one possessing a knowledge of meters and meter proving that to expect consistently reliable tests under such conditions is out of the question.

The periodical testing of consumers' meters is one of the necessary features of the gas business, and in most cases a profitable one for the companies. It seems most desirable that gas companies should make at least one test of every

meter in service after a period of years, the length of which should be determined by the summary of tests of meters removed from service, such summaries being arranged according to the years of service. Three years has been decided upon in some places as the maximum time that meters should remain in service without removal for test, but it is a debatable question whether this should not be extended to a longer period.

The summaries of all meters tests for a year in practically every instance show the net error to be slightly slow, averaging about one per cent. against the gas companies. When the results of tests are tabulated according to years of service since previous test, the net error consistently becomes slower as the length of service increases. This is true of both dipping and non-dipping meters, but it is probable that dipping meters will not continue to increase in slowness, as the years go by, at as fast a rate as do the non-dipping meters, although there has not been sufficient time, as yet, to demonstrate this point.

The practice of changing meters every three years, or after any other arbitrarily decided term of service does not appear as very intelligent handling of the meter question, either from the standpoint of protecting the consumer, or of safeguarding the gas companies' interests. One large company stopped its practice of changing meters after being in service three years, for the reason that the condition of the meters (all non-dipping) so changed, was found to be such as to render the expense and annoyance entirely unwarranted. This same company started a record of meter tests arranged according to years of service and according to class of meter. In the case of the non-dipping class of meters, it has shown that after seven years of service the net error slow increased rapidly, showing conclusively that meters of this class should be changed at the end of seven years, in order to protect the company against serious loss. The record in question also showed that the average fast error became smaller, while the

average slow error became larger as the number of years increased.

The records of dipping meter tests do not cover a sufficient number of years to date, to give any indication as to the maximum length of time that meters of this class may be allowed to remain in service without causing serious loss due to a slow net error.

Investigation has shown and undoubtedly will continue to show as a whole, that meters in service show a net error in favor of the consumer, this net error becoming larger in favor of the consumer as the length of service increases, so that any periodical changing of meters forced upon gas companies with the idea of protecting the consumer, does not work to that effect in practice, nor does it necessarily benefit the company, as the expense incurred in changing meters at intervals of every few years might greatly exceed any loss sustained due to slow error of the meters, if same were allowed to remain in the consumers' premises.

The only logical method of determining the number of years a meter should be allowed to remain in service is by careful study of summaries of proofs, kept according to years of service, and a determination of the cost of changing and testing the meters to offset the loss due to the slowness of the meters after certain length of service, any other method being unreliable and resulting in unwarranted expense.

The practice of several large gas companies of frequently changing large meters supplying gas continuously for a number of hours each day, to engines or other appliances, appears to be a good one. By this method the meters passing large quantities of gas are kept within smaller limits of error, the companies being subjected to less liability of loss of large quantities of gas due to slow registration of the meter, as might easily be the case were the large meters allowed to remain in service subject to the excessive wear of moving parts, due to the long continued period of operation at or near maximum capacity. Records of tests of large meters show, however, that they hold their proof equally as well as do

small meters for similar periods of service, so that it does not mean that because a meter is large in size or capacity, that it will become slow more easily than a meter of smaller size or capacity, but rather the conditions under which a meter is required to operate should be the important factor in determining the maximum period of time same should be allowed to remain in service.

Before leaving the subject of accuracy of consumers' meters, the prepayment meter mechanism should be considered. Every prepayment buying mechanism operates in conjunction with the index mechanism of the meter, so that any discrepancy between money lifted from cash box taken in consideration with the credit shown on the credit dial, and the meter index reading, is readily discovered by the clerks who post the consumers' ledgers. Any money lifted in excess of the index and credit shown, belongs to the consumer and should be returned to him or credited to his account on the gas companies books. Any shortage may be due to prepayment mechanism defects, to theft, to mistake of collectors in counting the money lifted or to other causes. When the shortage is sufficient to warrant removal of the meter and examination of prepayment mechanism upon removal shows that same is defective, thereby enabling consumer to obtain more gas than paid for, the gas company is justified in asking the consumer to pay the shortage, otherwise the loss is stood by the company. The operation of the prepayment mechanism of any meter is in no way affected by the error in proof of the meter. A prepayment meter geared for $1.00 gas will give a 250 cubic foot index reading for each quarter, regardless as to whether the meter is fast or slow.

The supposed incorrectness of the gas meter has been for many years the subject of newspaper jokes, and many present day consumers have the idea firmly rooted in their minds that the meter index reading has no relation to the quantity of gas actually consumed. The gas companies are partly to blame for this misconception of what is actually a very

accurate measuring device. Gas is so convenient and so easily wasted that nothing is easier than for a consumer to use a lot of gas between bill periods and to forget about it, or to have servants or children waste the gas to an extent, not much for any one day, but when spread over 30 or 90 days period, so large that the resulting bill makes him feel that he is being robbed. If no other advantage accrues to the gas companies in the practice of late, of appointing public service commissions whose duty is to test meters at the request of any consumer, one advantage will certainly result, in that the public will come to know what the gas companies have always known, that the error in gas meter registration is always very small, and in most cases in favor of the consumer.

In conclusion it may be truly said that gas companies and meter manufacturers thoroughly realize the absolute necessity of accuracy in gas meter registration and have worked hand in hand to attain the desired results and it is no exaggeration to say that the gas meter now occupies a splendid position as a remarkably accurate commercial gas measure.

THE PRESIDENT: Mr. Castor has given us a very interesting paper on a very interesting subject. Are there any questions?

MR. MCDONALD: I move a vote of thanks to Mr. Castor for his paper.

The motion was seconded and carried.

THE PRESIDENT: The last paper is on

REMOVAL OF ORGANIC SULPHUR FROM GAS.

BY MR. H. M. PAPST.

MR. MCDONALD: Mr. Papst is not here and the paper is very technical. Anybody who is interested in the subject will want it in his laboratory, but very few people could digest it

by hearing it, so I move that it be considered read, and printed in the minutes.

THE PRESIDENT: If there is no objection, gentlemen, the paper by Mr. Papst will be considered as read by title, and will be printed in the proceedings. There being no objection it is so ordered.

THE REMOVAL OF ORGANIC SULPHUR BY REHEATING.

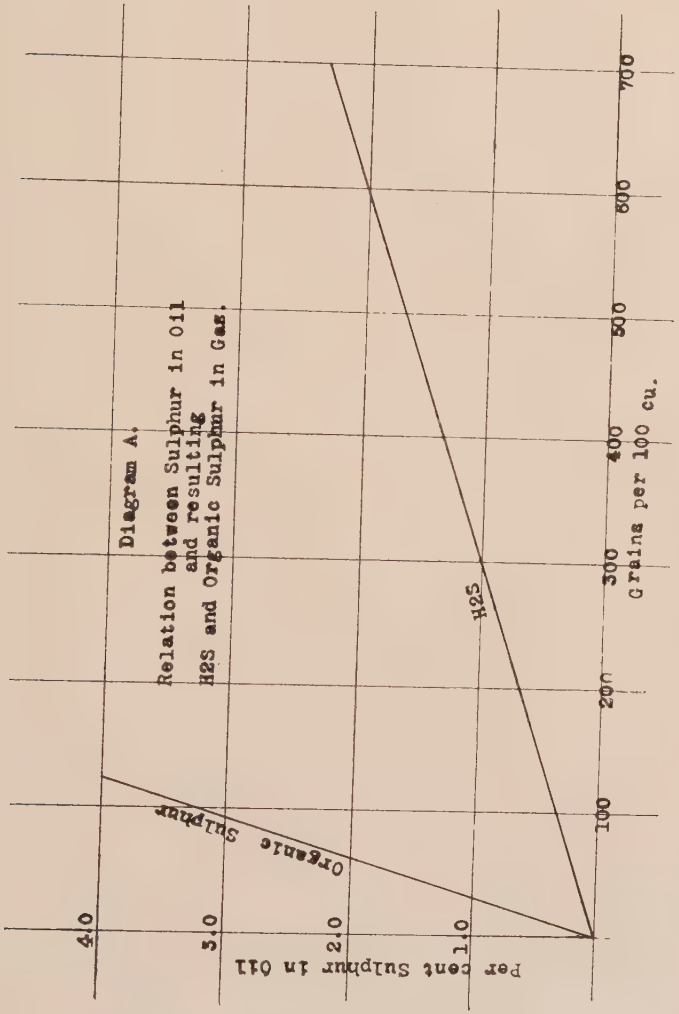
What it is:—The term "Organic Sulphur" is used to denote that portion of the sulphur in illuminating gas other than that in combination with hydrogen. Sulphur in the form of sulphuretted hydrogen is that part which is removed by the usual oxide of iron purifiers. The organic sulphur is not removed by this means, and generally not at all, unless special means are employed to eliminate it.

The sulphur in the form of sulphuretted hydrogen is tested for qualitatively by strips of paper impregnated with acetate of lead. Therefore, many gas men who are not chemists are not aware that a goodly proportion of the total sulphur is being distributed with the gas.

The organic sulphur consists mainly of bisulphide of carbon. The other principal organic combinations are thiophenes, mercaptans and sulpho-cyanides. Both sulphuretted hydrogen and the organic sulphur compounds originate, of course, with the sulphur in the gas making materials, whether coal or oil. Materials very high in sulphur will give a raw gas containing high percentages of both forms. Some coals and oils are so high in sulphur that they cannot be used for making illuminating gas, although they may be otherwise well adapted for the purpose. This has a tendency, of course, to narrow the selection of raw materials to those low in sulphur. Generally speaking, the amount of these impurities is directly proportional to the percentage of sulphur in the raw material.

The accompanying diagram shows the amounts to be expected when the gas is manufactured from crude oil alone.

How it occurs:—The study of these sulphur bodies has shown that they are generally formed at very high heats and



that the amount in grains per 100 cubic feet rises faster than the increased amount of gas obtained by higher heats. It

seems likely that there are secondary reactions taking place in the generator or retort whereby the sulphuretted hydrogen resulting from the decomposition of the sulphur bodies in the raw material recombines with the carbon or carbon compounds to form organic sulphur combinations. Even after the gas has left the place of generation, there seems to be a possibility of the further formation of organic sulphur. It has been observed that the amount of the impurity is lower in the finished gas when revivification takes place in the usual way, by blowing or sucking through a current of air, than when the same is accomplished by admitting continuously a small percentage of air and a periodical reversion of the position of the purifiers. This may be due partly to an actual cleansing of the material by the blowing, or possibly by secondary reactions taking place between the sulphuretted hydrogen and various organic bodies present in the oxide. The following has been suggested as likely to take place.

Hydrogen sulphide and thio-carbonilide can react as follows to form bisulphide of carbon and aniline:

$$CS\begin{matrix}NH.C_6H_5\\NH.C_6H_5\end{matrix} + H_2S = CS_2 + CS\begin{matrix}NH.C_6H_5\\NH.C_6H_5\end{matrix}.$$

This is liable to take place when the amount of hydrogen sulphide is relatively large, on account of the influence of mass action. The equation is capable of working backward, and is likely to do so should clean gas, free from hydrogen sulphide, be passed through a purifier which has not been revivified. In that case, it is possible for the clean gas to regenerate hydrogen sulphide and leave the box dirty. Such a reaction has been actually observed in practice. However, the sum total of the reactions amounts to not over nine or ten grains per 100 cu. ft. In oil gas, and coal gas as well, there are also cyanogen compounds which are capable of acting in the same manner.

Our first struggles and experiments leading to the reheating

process:—It was early recognized by this company that the expense of removing these impurities was insignificant in comparison with the benefits to be derived. This was even before the change of the generating process from water gas to oil gas. Water gas made from crude oil contained about 30 grains of sulphur per 100 cubic feet, and this amount, which most gas companies consider innocuous, was causing a great deal of complaint.

Of course, it was out of the question to distribute gas containing the greatly increased quantities due to the use of oil alone for gas making. Experiments were therefore instituted to find a better method than the old sulphided lime method. This method was tried and at once found to be uncertain and unsatisfactory. The sulphided lime has at times a tendency to increase instead of diminish the amount of impurities to be removed. The method will, with some uncertainty, remove from a third to a half of the organic sulphur at a cost of from three to four cents per thousand. The apparatus and ground space are about equal to that necessary for the hydrogen sulphide removal.

One of the earliest experiments was that of washing out the impurity with light tar oils and subsequently with crude oil. It both of these attempts the high vapor tension of bisulphide of carbon proved a bar to success, although quite successful for retaining naphthalene, which has a comparatively low vapor tension.

The idea of reheating the gas to cause a breaking down of the impurities was then tried on a comparatively large scale. The plant consisted at first of a 30 in. cast iron pipe filled with scrap iron heated in a brick oven and connected to two 6 ft. by 6 ft. purifiers. Owing to the large size of the pipe, the best result was 50 per cent. of the organic sulphur broken down to hydrogen sulphide. This arrangement was replaced by five 4 in. tubes and eight 3 in. tubes 8 ft. 6 in. long. The results were quite satisfactory and the tabulated data are as follows:

Flow of gas cu. ft. per hr.	Temperature deg. Fah.	Grs. of H_2S per 100 cu. ft. in reheated gas
19,700	662	15
17,000	860	15
15,000	932	25
14,200	770	50
10,200	968	50

The last test showed 65 per cent. of the impurity broken down.

Description of the Process:—Since the experiment showed the unsuitability of the tubes to reheat the gas, an internally heated apparatus was designed, large enough to handle the output of the works. It consists of two steel shells, similar to the ordinary water gas superheater, lined with fire-brick and filled with staggered checker work. Between these two is another shell or generator, similarly lined, but about half as high, equipped for burning either solid or liquid fuel. For this purpose it is connected up on either side with the bottom of the reheaters. The connections are provided with water cooled valves. The reheaters are provided with the regular stack valves and offtake pipes dipping into a common washbox. These shells are alternately heated from the central generator. The purified gas is alternately admitted to the bottom of each reheater and passes through the hot bricks, where the organic sulphur is broken down to hydrogen sulphide. After passing through the washbox, scrubber and condenser, it is purified from hydrogen sulphide in secondary oxide of iron purifiers, thence passing into the station meter. The apparatus is kept at about 1,200 Fahrenheit. The exhauster works continuously, since one reheater is always cut in before the other is taken off.

The plant is very cleanly and constitutes a show place. There are no nuisances in the way of by-products. Only one attendant is necessary during the day and one at night, working eleven-hour shifts, the plant being shut down from 7 A. M. to 9 A. M., while the oil gas sets are down. The washbox is never cleaned, since there is no tar or lampblack. The checker

work in the reheater should last indefinitely, as it is not subject to wear and tear.

While our plant is not equipped with regenerative effects, such will add materially to the efficiency of the process. The issuing gas will be made to preheat the entering gas by means of a heat exchanger similar to a condenser, whereby the fuel charges will be cut in half.

The ground space necessary for the reheater installation is about one-fifth of the generating capacity. That for the secondary purifiers is about a third of the primary capacity.

It is obvious that in case of disaster overtaking the gas making sets, we have in the reheaters admirable oil gas or producer gas generators.

The secondary purifiers are available to act as catch boxes for any traces of hydrogen sulphide, thus decreasing the amount of investment on the primary purifiers necessary to handle peak loads.

The life of the material in the secondary purifiers is from five to six times that of the primaries, due to the small amount of hydrogen sulphide to be removed and the perfect cleanliness of the reheated gas.

Results of reheating the gas:—The apparatus will remove with the utmost certainty 70 per cent. of the total organic sulphur. Inasmuch as there is no tar or lampblack produced by heating the gas in this manner, the overflow water being absolutely clear, the hydrocarbons are but slightly affected. As a result, the candle-power losses are insignificant. This is in any case a matter of indifference, as the oil or coal per M is the same whether the splitting off of hydrogen necessary to bring the gas down to the required candle-power is performed in the generator or the reheater. One gets the increased volume in either case.

Theory of the reheating process:—Since it is well known that the higher temperatures are favorable to the production of larger amounts of the organic sulphur, it seems possible that an action similar to that of the decomposition of steam by incandescent carbon may take place.

The reaction for the formation of water gas is at the first stage as follows:

$$2H_2O + C = 2H_2 + CO_2.$$

This reaction is the more efficient in volume with increased heats, as shown by Bunte's experiments. We are now reminded that sulphur is of the same chemical family as oxygen, and let us replace the oxygen in the above equation by sulphur, we obtain:

$$2H_2S + C = 2H_2 + CS_2.$$

This analogy holds good in every way we look at it, but more especially when we come to reverse the equation as in the reheating process. It is more than likely, therefore, that the carbon bisulphide is in the process combined with nascent hydrogen either from water vapor or hydrocarbons, as follows:

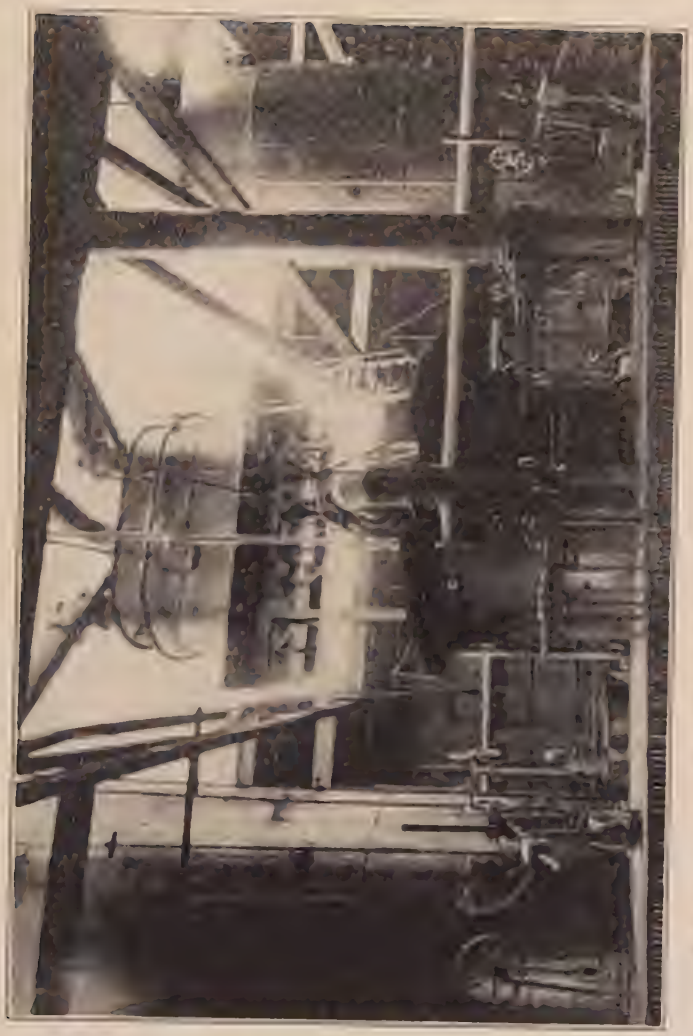
$$CS_2 + 2H_2 = 2H_2S + C.$$

$$\text{or } CS_2 + 2H_2O = 2H_2S + CO_2.$$

Now reversible reactions are rarely complete. There is always a balance established between the two sides of the equation, on account of the law of mass action, according to which there is a continual interchange of atoms from one side to the other. According to the functions of the reaction, the balance is more or less in favor of one side. This condition persists until the conditions are changed or until some of either side is removed from the sphere of reaction. This will enable a readjustment which will again persist.

Now, in the generator we have established an equilibrium between the hydrogen sulphide and the bisulphide of carbon, which under oil gas conditions and temperature is about 8 or 9 to 1. By purification and carbon removal we eliminate one side of the equation. When we reheat, therefore, we enable the other side, in this case the carbon bisulphide, to redistribute itself according to the same ratio into a fresh portion of the hydrogen sulphide and a small remainder of carbon bisulphide. Should we reheat at lower temperature, less carbon bisulphide would revert to hydrogen sulphide. At 1,200 degrees Fahrenheit the ratio is about 3 to 1, which is very near-

ly sufficient for our purpose. Therefore, the reheating process is merely reestablishing the temperature of reaction in the



Reheating process at the plant of the Portland Gas & Coke Company, Portland, Ore.

generator after the elimination of a part of the equation by purification. For a second reheating, the hydrogen sulphide

removed from the first reheating would in turn do the same, and so on.

Cost of operating:—The plant has been in successful operation at the works of the Portland Gas and Coke Company since August, 1908. The good results obtained from the use of this process have shown themselves not only in the laboratory, but also in the plainly expressed satisfaction of the public. Information as to the operating cost of the plant can best be furnished by submitting the figures for 1909 of the Portland Gas and Coke Company. The figures for amount of sulphur remaining after reheating and secondary purification, being monthly averages of street gas and including setbacks from various causes, such as small purifying capacity and poor purifying material of the secondary purifiers and lack of blast pressure, hardly do the process full justice. The total amount of gas reheated was 817,000,000 cubic feet, with a maximum per day of 4,000,000 cubic feet.

			Grains of organic s. per. 100 cu. ft.		
Month	Heating oil gals per M.	Labor c. per M.	Before	After reheating	Amt. removed
Jan.	0.35	0.0026	58.8	16.9	41.9
Feb.	0.21	0.0025	50.0	17.3	32.7
Mar ...	0.18	0.0030	49.0	15.5	33.5
Apr. ...	0.50	0.0042	58.8	14.2	44.6
May ...	0.49	0.0032	53.9	15.3	38.6
June ...	0.55	0.0031	68.5	18.0	50.5
July ...	0.56	0.0035	68.9	20.8	48.1
Aug. ...	0.48	0.0031	66.7	18.2	48.5
Sept. ...	0.42	0.0026	57.8	14.7	43.1
Oct.	0.33	0.0024	62.3	15.5	56.8
Nov.	0.31	0.0020	62.1	18.8	43.3
Dec. ...	0.30	0.0018	49.2	18.1	31.1
Annual report	0.35	0.0026	58.8	16.9	42.9

I would consider the following a fair average of what the plant will do:

0.50	0.0026	60.0	13.0	47.0

Conclusions:—The reheating process has opened the door to the use of inferior grades of gas coals and oils low in price, which heretofore could not be used on account of their high sulphur contents. A difference of only fifty cents per ton in the price of two coals, one high and one low in sulphur, means four cents increased profits per 1,000 cubic feet in the holder, allowing one cent per 1,000 cubic feet for the removal of the additional sulphur and interest on plant investment.

Clean gas is the best asset a gas company can have. Any reasonable expense at the works that will produce satisfied consumers is money well invested. Experience shows that satisfied consumers produce an increased return per mile of main investment. On the other hand, a dissatisfied public invites hostile legislation and unprofitable competition.

Now, gentlemen, we have a little routine business to transact. The first will be the appointment, as is the custom, of the

COMMITTEE ON PUBLIC RELATIONS AND THE TECHNICAL COMMITTEE.

I have been requested by Mr. McDonald, the president elect, to name the following gentlemen for the Public Relations Committee:

JOHN WILLIAMSON, Chairman.

W. F. DOUTHIRT — E. C. JONES

A. C. HUMPHREYS — C. F. PRICHARD

S. J. GLASS.

TECHNICAL COMMITTEE.

W. H. FULWEILER, Chairman,

V. F. DEWEY — M. WEBB OFFUT

W. E. MCKAY — J. M. MOREHEAD

HENRY L. DOHERTY

That concludes the appointment of the General Committees for the next year, by request of the President-elect.

The next thing is the

REPORT OF THE COMMITTEE ON THE PRESIDENTIAL ADDRESS.

MR. EDWARD G. PRATT, Chairman.

Mr. Pratt then read the following report:

REPORT OF COMMITTEE ON PRESIDENT'S ADDRESS.

Mr. President and Gentlemen of the American Gas Institute:

The Committee, to which was referred the address of the President, beg leave to report as follows: Your Committee commend for your thoughtful consideration the business-like, practical and timely address of the President and suggest the careful reading of it because there are thoughts suggested therein which are of vital importance to the welfare of the Institute at this time. In making this statement your Committee has in mind more especially that portion of the address which refers to the success and life of the Institute, and what was anticipated in its organization when the three older associations were consolidated into this one.

Your Committee is in hearty accord with what the President suggests respecting the preparation of papers, the work and assistance given by those who are carrying on the affairs of the Educational Class; also what he says respecting the "single standard" instead of "separate standards" for light and power.

We heartily approve of the ideas advanced respecting "government by commission" and what he says respecting the policy of Public Utility Companies and their treatment of their customers in the communities in which they are doing business.

It may be outside the province of this Committee to refer to the question of membership, but it appears to it that the net increase of membership in this Institute is by no means what it ought to be, and it is the business of the officers to ascertain the causes for this comparatively small increase and apply the remedy that will be the means of producing better and more healthy results in this respect; and the duty of the members to help increasing this membership by rendering all the assistance

possible toward making the Institute the power for good to its members, and to the business, which was anticipated when organized.

PAUL DOTY,
JOHN WILLIAMSON,
EDWARD G. PRATT, Chairman.

A motion was then duly carried that the report of the Committee on the President's address be adopted as read and placed on the minutes.

THE PRESIDENT: Next is the

REPORT OF THE COMMITTEE ON NEXT PLACE OF MEETING.

Mr. A. E. Forstall read the following report:

Your Committee on Place of Next Meeting report as follows:

Representatives of the Chamber of Commerce and the City Government of Richmond, Va. presented to us a very hearty invitation to hold the next meeting in that city. This invitation was also given in letters from the Governor of Virginia and the Mayor of Richmond. Your Committee wishes to express its deep appreciation of the spirit which prompted the presentation of this invitation verbally by personal representative of the organizations named and of the eloquence and cordiality with which it was delivered. We also appreciate the attractions of Richmond as a Convention City.

It has also been suggested to the Committee that St. Louis, Mo., would be an appropriate place for the meeting.

There have, however, been presented to the Committee important reasons for not making any definite recommendation now, and we therefore ask permission to defer making any recommendation at this time with the understanding that we will report later to the Board of Directors and that the Board of Directors will have power to act upon this report when made.

There have been handed to the Committee telegrams from the Mayor of New Orleans inviting the Institute to hold its 1915 meeting in that city. The Committee having no jurisdic-

tion in this matter have returned the telegrams to the Secretary without action.

Jas. W. Dunbar,
J. M. Morehead,
A. E. Forstall, Chairman.

The President: Gentlemen, you have heard the report of the Committee on the Next Place of Meeting. What is your pleasure?

Mr. Egner: If I am in order I should like to offer a resolution of an amendment to that report. I should like to move that the next meeting of this Association be held in Richmond, Va. We have met twice in New York, once in Chicago, once in Detroit and once in the District of Columbia. The Institute has never gone south. Now we have received a very courteous invitation to go there and we have the assurance of ample accommodations, historic interest and a hearty welcome, and I do not see the use of letting that lie over. I can say personally that I believe that each member of that Committee that has just reported would be willing to go to Richmond, and I think there is nothing to be gained by delay. If it is in order I would move that the American Gas Institute shall meet in 1911 in the City of Richmond, Va.

Mr. McDonald: I presume discussion on that motion is in order and I want to say that there is a most excellent reason for according to the committee the additional time for which they have asked. The Commercial Gas Association, of which a great many of our members are also members, has requested us to defer settling that question until their meeting, when they can appoint a similar committee.

Mr. Egner: The American Gas Institute was formed by the union of the American Gaslight Association, the Western and the Ohio Associations, and soon after that some gentlemen started two other associations, and many of us joined them. Now we don't want to wait and see what they decide on. I think the American Gas Institute can decide for itself and do it right now.

There were calls for the question.

THE PRESIDENT: Gentlemen, it has been moved and seconded that the next meeting of the Institute be held in Richmond. I will put this motion first and depend upon the vote whether I am to put the other one. All in favor of Mr. Egner's motion to meet in Richmond, Va., next year, will signify by saying Aye. (One aye) Contrary minds, No. (Noes)

THE PRESIDENT: It is lost.

MR. MCDONALD: I should like to add to my motion, that the committee be continued for that purpose.

THE PRESIDENT: Now I will put the motion made by the president-elect; that the place of meeting for 1911 be left for the present with the Committee to consider and to report to the Board of Directors, and that the Committee be continued until the conclusion of their work. Are you ready for the question?

The question was called for, and on being put to a vote, was carried.

MR. MCDONALD: Gentlemen, I hope and feel that this action does not at all preclude the committee from deciding on Richmond, Va. If I had nothing to consult but my personal feelings in the matter, that is where I should like to go.

THE PRESIDENT: Section 10 of the By-laws and section 33 of the Constitution provide that a meeting of the directors shall be held immediately after the session, in order to elect a Finance Committee and a Membership Committee. The conditions are such that that meeting can only be held to-morrow on the excursion boat, and I trust there will be a sufficient number of the directors present to enable us to form a quorum and have a meeting in accordance with those two sections.

MR. MCDONALD: I want to move a vote of thanks to the Committe on Arrangements and its various subcommittees. I do not think a convention has ever been better taken care of, and things have worked more smoothly and with more forethought for the comfort of the members than ever before.

Several members seconded the motion.

THE PRESIDENT: It has been regularly moved and seconded that a vote of thanks of the Institute be tendered to the Committee on Arrangements and the various subcommittees, for the efficient manner in which they have performed their duties at this meeting. All in favor of that motion will signify their consent by saying Aye.

The motion was carried unanimously amid applause.

MR. MCDONALDS I don't want to slur over that matter by including everything in one motion. The officers of the New York Edison Company have favored this convention with a great courtesy, and the officers of the United States Navy Yard have presented them an invitation giving them the freedom of the yard. I move a vote of thanks of the Institute to the officers of the New York Edison Company and to the officers of the United States Navy Yard.

The motion was duly seconded and carried.

THE PRESIDENT: Is there anything else that any member wishes to offer before we take a recess?

MR. PRATT: I do not know whether Mr. McDonald's motion covers the thanks of the Institute to anyone except the Committee on Arrangements. If it did not, I should like to make a motion that the thanks of the Institute be extended to the President and officers of the Institute for the performance of the work incidental to their respective offices. No one except those who have occupied similar positions understand the vast amount of work in the preparation for such a meeting as this. Their success in that work has been so complete and perfect that I move a vote of thanks be extended to the President and his associates.

MR. MCDONALD: I second Mr. Pratt's motion.

THE PRESIDENT: I am a little bit embarrassed, gentlemen, at putting that motion.

MR. MCDONALD: I will put the motion. Those in favor of Mr. Pratt's motion thanking the President and the other officers of the Institute for their arduous and successful labor will signify the same by saying aye. Carried.

THE PRESIDENT: Speaking for the President—and I think for the other officers—I believe they feel they have been amply repaid by the attendance and courtesy shown by the members and by the way they have borne with us when we have run overtime. I thank you, gentlemen.

If there is nothing more, the meeting will now take a recess and finally adjourn at four o'clock to-morrow afternoon at the conclusion of the excursion.

(The Convention then adjourned at 5 P.M.)

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of the

American Gas Institute

1910-1911

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First Vice-President

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1910-1911

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J. F. Wing

Consumers Meters

Chas. C. Schiller, Chairman
W. K. Harrington
W. A. Castor
J. A. Gould
Donald McDonald, (Albany)

Place of Next Meeting

A. E. Forstall, Chairman
J. M. Morehead
Jas. W. Dunbar

CONSTITUTION AND BY-LAWS

OF THE

American Gas Institute

Constitution.

NAME.

SECTION 1. The name of this association shall be the AMERICAN GAS INSTITUTE.

OBJECTS.

SECTION 2. The objects of this Institute are to amalgamate into one body the American Gas Light Association, the Ohio Gas Light Association, and the Western Gas Association, and to facilitate co-operation between the various state and district associations that now exist, or may hereafter be formed within the territory covered, and to secure thereby the more rapid promotion and advancement of scientific and practical knowledge in all matters relating to the construction and management of gas works and the manufacture, distribution and consumption of gas; the firmer establishment and maintenance of a spirit of fraternity between those interested in the gas business by affording opportunity for social intercourse and friendly interchange of information and ideas; the inducement and extension of more cordial and friendly relations between gas companies and consumers of gas based upon their mutual interests, and the education of employees of gas companies to enable them to better perform their duties. Also to take over such property and assets of the associations named as may be legally invested in the Institute.

MEMBERS.

SECTION 3. The membership of the Institute shall consist of Honorary Members, Active Members, Junior Members and Associate Members. Honorary Members, Junior Members and Associate Members shall not be entitled to vote nor to hold office, but shall be entitled to all the other privileges of membership.

SECTION 4. Honorary Members shall be persons whose scientific or practical knowledge in matters relating to the gas industry, and whose efforts and interests in that behalf shall recommend them to the Institute.

SECTION 5. To be eligible to Active Membership, a person must be at least 26 years of age, and be an officer or other employee of a Gas Company; or a Consulting Gas Engineer, or an employee of a Consulting Gas Engineer. He must be competent to act efficiently as the Manager of a department of a Gas Company's business and must have his chief interest in the gas business directly connected with the manufacture, sale, or utilization of gas, and not the manufacture or sale of apparatus or appliances used by Gas Companies.

SECTION 6. To be eligible as a Junior Member, a person must be over 20 years of age and be in the employ of a Gas Company, or of a Consulting Gas Engineer, and must be qualified either by experience or education to hold a responsible position under such employers.

SECTION 7. To be eligible as an Associate Member, a person must be engaged in a pursuit which constitutes a branch of gas engineering, or be otherwise qualified to assist in promoting the objects of the Institute.

SECTION 8. Charter Members shall be such of the present membership of the American, Ohio, or Western Gas Association as shall be certified by the officers of the same to the Directors of the Institute as qualified respectively for Active, Junior or Associate membership, provided that to become a

charter member, it shall be necessary for each person so certified to make application to the Directors of the Institute within a period of sixty days after notice has been sent him of the formation of the Institute.

ELECTION OF MEMBERS.

SECTION 9. Honorary Members shall be proposed by the Directors to the members of the Institute by mailed notifications immediately after any annual meeting, and shall be voted upon by letter ballot at the time of the regular September ballot next following.

SECTION 10. Every application for either Active, Junior or Associate Membership shall be made to the Secretary in writing upon a form approved by the Directors, upon which shall be set forth as the grounds of the application a complete account of the qualifications and experience of the applicant and his agreement to conform, if elected, to the Constitution, By-Laws and Rules of the Institute, and shall be endorsed by at least two Active Members to whom the applicant is personally known. The Secretary shall submit each application to the Directors, who shall consider and act upon it and assign the applicant to the grade of membership to which, in their judgment, his qualifications entitle him. The name of each candidate thus approved by the Directors shall, unless objection is made by the applicant, be submitted to the voting membership for election by means of a letter ballot.

SECTION 11. It shall be competent for any Junior or Associate member to apply for transfer to another grade of membership. The application for such transfer shall be made in the same manner as in the case of a new applicant.

SECTION 12. Election to membership shall be by a sealed letter ballot, as the By-Laws shall provide. Adverse votes to the number of 2 per cent. of the votes cast shall be required to defeat the election of an applicant for any grade of membership. The Directors may, in their discretion, order a second

ballot upon a defeated applicant, in which case adverse votes to the number of 4 per cent. of the votes cast shall be required to defeat the election.

SECTION 13. Any person elected to the Institute, except Honorary Members, must subscribe to the Constitution and pay to the Treasurer the initiation fee and one year's dues for his grade of membership before he can be entitled to the rights and privileges, or can receive a certificate of membership. If this requirement is not complied with within six months of the notification of the election the applicant will be deemed to have declined the election and the election shall be void.

INITIATION FEES AND DUES.

SECTION 14. The initiation fee for membership in each grade shall be as follows:

For Active Members	$15.00
For Associate Members	15.00
For Junior Members	5.00

These initiation fees shall not include the dues for the current year in which the applicant is elected.

SECTION 15. A Junior Member, on promotion to any other grade of membership, shall pay an additional fee of $10.00, except that Charter Junior Members shall not be required to pay such additional fee. No person shall retain Junior membership for more than two years after becoming qualified for active membership.

SECTION 16. The annual dues, payable in advance, for membership in each grade shall be as follows:

For Active Members	$10.00
For Associate Members	10.00
For Junior Members	5.00

SECTION 17. The Directors may in their discretion permit any Active or Associate Member to become a Life Member

in the same grade by the payment in one sum of an amount sufficient to purchase from a reputable life insurance company an annuity on the life of a person of the age of the applicant equal to the annual dues in his grade of membership. Such life member shall not be liable thereafter for annual dues. Life members of the associations dissolving shall only be required to pay the difference, if any, between the sum computed as above and that already paid for their present life membership.

Section 18. The Directors shall have power by letter ballot to admit to Life Membership, without the payment of a life membership fee, any person who for a long term of years has been an active or an associate member, when, for special reasons, such an action would, in their judgment, promote the best interests of the Institute. Notice that such action as proposed shall have been given at a previous meeting of the Directors, and one dissenting vote shall defeat the proposed action.

SUSPENSIONS AND EXPULSIONS.

Section 19. A member whose dues for a year completely expired are not paid, shall not be entitled to vote, nor to participate in the deliberations of the Institute, nor to receive a copy of the proceedings. Any member whose dues shall remain unpaid for a term of three years may be dropped from the roll of membership by a vote of the Directors. A member dropped for non-payment of dues may upon paying the amount he owes the Institute, be reinstated at the option of the Directors.

Section 20. The Directors may refuse to receive the dues of any member of any grade who shall have been adjudged by them to have violated the Constitution or By-Laws of the Institute, or who, in their opinion, shall have been guilty of conduct rendering him unfit to continue in its membership, and such person may be expelled from the Institute upon a recommendation to that effect made by the Directors at any general meeting of the Institute. The vote upon expulsion

shall be by ballot and shall require two-thirds of the votes cast for its adoption.

SECTION 21. The Directors may transfer any member from his then present to any lower grade of membership. They may also refuse to receive the dues of any member who is no longer eligible to any grade. No transfer of grade shall be made, or refusal to accept dues recorded, except upon notice from the Secretary, whose duty it shall be to give such notice, that said member is no longer eligible for membership in his then present grade, and that said member has for a period of ninety days after notification of such non-eligibility, failed to apply for transfer. The vote in each case shall be by ballot, and shall require two-thirds of the votes cast for its adoption.

MANAGEMENT.

SECTION 22. The affairs of the Institute shall be managed by the Directors, subject to the control of the general meeting.

SECTION 23. The Board of Directors shall consist of the President, the two Vice-Presidents, the Secretary, the Treasurer, the Junior Past-President, and until changed as hereinafter provided for, ten Active Members of the Institute. Five members shall constitute a quorum for the transaction of business. If arrangements are made for co-operation between the Institute and district and state gas associations, as hereinafter provided for, the number of members of the Board elected from the Active Members of the Institute shall be increased from time to time, as it becomes necessary, in order to keep the number of Directors elected by the Institute equal to not less than two-thirds of the total number of both Institute and Associate Directors.

SECTION 24. Should a vacancy occur in the Board of Directors or in any elective office, except the Presidency or First Vice-Presidency, through death, resignation or other cause, the Directors may elect an Active Member to fill the vacancy until the next annual election.

SECTION 25. The Directors shall regulate their own proceedings, and may, by resolution, delegate specific powers to an Executive Committee, or to any one or more of their members. No act of the Executive Committee, or of a delegate, shall be binding until it has been approved by a resolution of the Directors.

SECTION 26. The Board of Directors shall present at the annual meeting of the Institute a report verified by the President, Secretary and Treasurer, or by a majority of the members which shall show the state of the finances of the Institute at the date of the report; the receipts and expenditures for the fiscal year immediately preceding; the names and places of residence of the persons who have been admitted to membership in the Institute during that year, and give an account of the action taken by the Directors upon matters coming before it and recommendations as to the action to be taken by the Institute. This report shall be filed with the records of the Institute and an abstract of it shall be entered in the minutes of the proceedings of the annual meeting.

OFFICERS.

SECTION 27. At each annual meeting there shall be elected from among the Active Members a President, two Vice-Presidents, a Secretary, a Treasurer, and until otherwise provided for, five members of the Board of Directors. All of the officers shall be elected for one year, but the members of the Board of Directors shall be elected for two years. At the first general meeting ten members of the Board of Directors shall be elected, five to hold office for one year and five to hold office for two years.

SECTION 28. All elections shall be by ballot.

SECTION 29. The term of all elected officers shall begin on the adjournment of the annual meeting of the Institute at which they were elected. Officers shall continue in their respective offices until their successors have been elected and have accepted such election.

SECTION 30. The President and the retiring Active Members of the Board of Directors shall not be eligible for re-election the following year.

SECTION 31. Previous to each annual meeting it shall be the duty of the Directors to appoint a nominating committee of five members, none of whom shall be a Director. It will be the duty of this nominating committee to present at the annual meeting a list of the Active Members and Directors whom they recommend as officers for the ensuing year.

SECTION 32. Twenty or more members entitled to vote may constitute themselves a special nominating committee with the same powers as the nominating committee appointed by the Directors.

SECTION 33. The Directors shall appoint from their own number immediately after the meeting at which they are elected a finance committee of three members.

SECTION 34. The President shall take the chair at all meetings at which he is present. He shall determine to which general committee any matter shall be referred.

SECTION 35. In the absence of the President one of the Vice-Presidents shall take the chair, and in the absence of the President and Vice-Presidents a Chairman shall be appointed by the Directors from among their own members.

SECTION 36. The duties of the Secretary shall be to take minutes of all proceedings of the Institute and of the Board of Directors, and to enter them in proper books for that purpose. He shall conduct the correspondence of the Institute, read minutes and notices of all the meetings, and also such papers and communications as are considered in the absence of their authors, and perform whatever other duties may be required in the Constitution and By-Laws appertaining to this department.

SECTION 37. The duties of the Treasurer shall be to receive and keep all annual dues and funds of the Institute, to

keep correct accounts of same, and pay all bills approved by the President and a member of the Finance Committee, and he shall make an annual report to be submitted to the Institute.

SECTION 38. The duties of the Finance Committee shall be to audit the books, accounts and statements of the Treasurer; to invest the funds of the Institute, and to care generally for the finances of the Institute, subject to the control of the Directors.

SECTION 39. The duties of the Directors shall be to have the general management of the affairs of the Institute, and to prepare for its meetings. No paper or report that has not had the approval of the Directors shall be read at any meeting.

The Directors shall have the power to appoint, from time to time, a Committee on Arrangements from among the members to assist the Board of Directors in arranging for the meetings of the Institute. The Directors shall have power to fill for the unexpired term, any vacancies occurring by death, or resignation, in their own number, or the general committees.

Any resolution, report or recommendation, that has not been considered and approved by the Directors, and that in the opinion of the Chair would have the effect of changing the policy of the Institute, or committing it to any new policy or opinion to which it had not theretofore been committed, should be referred, before adoption, to the Board of Directors, whose duty it shall be to report to the next regular meeting of the Institute upon such committal, if any, and its proper phrasing.

SECTION 40. There shall be two general committees, each reporting to the Board of Directors and responsible to the Board for such part of the work of the Institute as is delegated to it in accordance with the provisions of Sections 34, 41 and 42. Each committee shall be composed of six members, to be appointed each year by the President, and to serve one year.

SECTION 41. One general committee shall be called the

Public Relations Committee, and to it shall be referred all investigations, reports, recommendations, resolutions and matters of any kind affecting the relations between the Institute, or its members, and the public, or any governing bodies, except as herein provided.

SECTION 42. One general committee shall be called the Technical Committee, and to it shall be referred all investigations, reports, recommendations, resolutions and matters of any kind having to do with the construction, operations and extension of gas works, and the conduct of the affairs of gas companies, not specifically delegated to the Public Relations Committee by Section 41, and except as herein otherwise provided.

SECTION 43. Each general committee shall have the power to appoint subcommittees. Each subcommittee shall consist of one member of the general committee, the other members being taken from the general membership of the Institute, and shall exist at the pleasure of the general committee by which it was appointed, and to which its report shall be made.

MEETINGS AND PROCEEDINGS.

SECTION 44. The annual meeting of the Institute shall be held on the third Wednesday of October of each year, at such place as shall be designated by the Institute at the previous meeting. In case of emergency the Directors shall have the power to change the time or place of meeting, or both, as so designated, by a three-fourths vote of all its members, at the call of the President, and such vote may be taken by mail.

SECTION 45. The Secretary shall send notices to all members of the Institute at least fourteen days before each general meeting, mentioning the papers to be read and any special business to be brought before the meeting.

SECTION 46. Special meetings of the Institute may be called at the option of the Directors, and the Secretary shall call a special meeting on the written request of one hundred members.

The notices for special meetings shall be sent to all members at least three weeks before the date for which the meeting is called and shall state the business to be transacted, and no other shall be entertained.

SECTION 47. Thirteen members shall constitute a quorum.

SECTION 48. All questions, except as otherwise provided in Sections 9, 20, 28, 49 and 57, shall be decided by any convenient system of open voting, the presiding officer to have a second or casting vote when necessary.

SECTION 49. Questions of a personal nature shall be decided by ballot, and all parliamentary procedure not specifically covered by this Constitution shall be governed in accordance with Robert's Rules of Order.

SECTION 50. Any member, with the concurrence of the presiding officer, may admit a friend to each meeting of the Institute but such person shall not take part in any of the discussions, unless permission to do so be given by the meeting.

SECTION 51. All papers read at the meetings of the Institute must relate to matters, either directly or indirectly connected with the objects of the Institute, and must be approved by the Directors before being read.

SECTION 52. All papers, drawings or models submitted to the meetings of the Institute shall be and remain the property of the authors.

SECTION 53. The President, the Junior Past-President, the First Vice-President, the Junior Past-Chairman of the two general committees, and the Secretary shall constitute a Publication Committee, and nothing shall be included in the published reports of the Institute's Proceedings, or in any other publication issued by its authority, that has not been approved by at least two-thirds of the full membership of the Publication Committee.

SECTION 54. The Directors shall meet the day before each general meeting of the Institute, and also on such day between

June 1st and September 15th, both inclusive, as may be designated by the President by notice given at least one week in advance of meeting. Special meetings may be called when the President shall deem it necessary, and the President shall be required to call a special meeting at any time on the written request of five members of the Board. Of such meetings reasonable notice shall be given by special call, in print or writing, specifying the business to be attended to.

AFFILIATION WITH LOCAL ASSOCIATIONS.

SECTION 55. The Board of Directors may in its discretion make with any one (or each) of the district and state gas, or gas and electric, associations now existing or hereafter to be formed, agreements for co-operation between the Institute and such associations. Each and every such association with which such agreements are entered into, shall covenant as follows: Not to elect to voting membership any person connected in any way with the gas industry, who is not directly identified with gas, or electric interests, within the state or district designated by the name of the association; and to consult with the Institute before undertaking any original work of interest to the gas profession. All original work carried on by an affiliated association under this agreement shall, when completed and accepted by this association, be presented to the Institute for approval, and when so approved shall be incorporated in the Proceedings of the Institute in such form as the Directors shall determine. Each and every such association shall during the continuance of such agreements, be entitled to elect one of its members a member of the Board of Directors of the Institute, the members so elected to be in addition to those named in Section 23, provided that the number of such associated Directors shall never exceed one-third of the total membership of the Board. Should the Board of Directors provide for an executive committee, this committee shall include in its membership one man from each of the affiliated associations as long as the number of such associations does not exceed six. Thereafter there shall be

on the executive committee at least six men who are members of affiliated associations and have among them membership in at least six such associations.

PROCEEDINGS.

SECTION 56. Each member of the Institute in good standing shall be entitled to and shall be furnished by the Secretary with a copy of the Proceedings of the Institute for the current year, in which shall be listed the names and addresses of the members. In any such list each member should be listed by the title or titles, only, from which he derives his eligibility to his class of membership.

AMENDMENTS.

SECTION 57. All propositions for adding to or altering any of the provisions of the foregoing Constitution shall be laid before the Directors, who, if they see fit, may bring it before the next general meeting of the Institute and who shall be bound to do so on the requisition in writing of any ten members of the Institute. All such propositions shall be decided by ballot and shall require two-thirds of the vote cast for their adoption.

By-Laws.

(Section numbers refer to corresponding Sections of the Constitution.)

1. (SECTION 10.) Each member proposing a candidate for admission is required to make a confidential communication to the Secretary for forwarding to the Membership Committee, setting forth in detail such information, personally known to referee, as shall enable the Directors to decide upon the eligibility of the candidate for admission to the Institute, except that in the event of the requisite number of members in good standing having personally signed the application of a candidate, this may be deemed sufficient endorsement and the requirement of the confidential communication referred to above shall not be obligatory, but shall be optional at the discretion of the Membership Committee. The Secretary shall be the judge of the competency and the signature of referees.

2. (SECTION 10.) In the absence of replies from the referees to inquiries for information, or if replies are not sufficiently explicit, the Secretary shall cause the applicant to be notified, and the application shall be held in abeyance.

3. (SECTION 10.) Immediately after the meeting at which they are elected, the Directors shall appoint from among their own number a Membership Committee of five members. They shall pass on all applications for membership and report to the Directors. Any correspondence in regard to an applicant shall be destroyed when his name has been placed on the voting ballot, or upon withdrawal of the application.

4. (SECTION 12.) The Secretary shall, twice a year, on or about the first day of March and September, mail to each member entitled to vote, a ballot stating the names and respective grades of the candidates for membership in the Institute which have been approved by the Directors, and the time of the close of voting. The voter shall prepare his ballot by crossing out the names of candidates rejected by him, and shall enclose said ballot in a sealed blank ballot envelope, which he shall then enclose in a second sealed outer envelope on which

he shall, for identification, write his name in ink. The ballot thus prepared and enclosed shall be mailed or delivered unopened to the Secretary, which shall be counted as an affirmative vote on all the names not crossed out. The Secretary shall be the judge of the competency and the signature of all voters. On the close of the voting, the Secretary shall first open and destroy the outer envelopes, and shall then canvass the ballots, and certify the result to the Membership Committee.

The Secretary shall not receive any ballot after the stated time of the close of voting. A ballot without the endorsement of the voter, written in ink on the outer envelope, shall be considered as defective, and rejected by the Secretary.

The names of those persons elected to membership, with their respective grades, shall be embodied in a written report, signed by the Secretary, and presented to the next meeting of the Institute. The President shall then declare them duly elected to membership in the Institute. The Secretary may, in advance of any meeting, advise each candidate of the result of the canvass of the votes in his case. The names of applicants who are not elected shall neither be announced nor recorded in the Proceedings.

The endorser of an applicant who has not been elected, may, with his consent, present to the Directors a written request for a re-submission of his name to ballot. The Directors may, in their discretion, by three-fourths vote of the members present, order the name of the applicant placed on the next ballot for members.

5. (Section 13.) Section 13 of the Constitution shall be printed upon the notification of election to all members except Honorary Members.

6. (Sections 14 and 16.) The initiation fee and annual dues of the first year shall be due and payable on notice of election to membership. Bills for the fee and dues should accompany the notification of election. Thereafter the annual

dues shall be due and payable on the first day of October of each year.

7. (Sections 14 and 16.) Upon payment of the initiation fee and annual dues, a newly elected member shall receive a copy of the volume of the proceedings containing the report of the meeting held in the then current fiscal year, and copies of any other publications of the Institute, which may have been distributed without charge to the members during that year, even though the date of issue of these publications is prior to that of the election of such member.

8. Each member shall be entitled to a badge upon payment of an amount to be fixed from time to time by the Directors. Upon his ceasing to be a member, he shall return his badge, and receive therefor the sum of $2.00.

9. Each member shall be entitled to a certificate of membership in accordance with his grade, signed by the President and Secretary. Every such certificate *shall remain the property of the Institute* and shall be returned to the Secretary on demand of the Directors.

10. (Section 19.) The Treasurer shall present to the Directors the name of any member in arrears for more than one year.

11. (Section 26.) The Secretary shall furnish the Directors with the information needed for their annual report, excepting only as to finances, or to matters which have been entrusted to special committees. The financial report shall be made by the Treasurer to the Finance Committee.

12. (Section 26.) The fiscal year of the Institute shall begin September 1st.

13. (Section 28.) The President shall, at the first session of the Annual Meeting, appoint three Tellers of Election, who shall canvass the vote cast for officers, and report the result to the meeting.

14. (SECTION 31.) The Nominating Committee shall report at the first session, and a ballot be taken on their report at once, unless twenty or more members object. In such case, the ballot for officers shall take place at the first session of the second day, in the manner prescribed in By-Law No. 15.

15. (SECTION 31.) If the report of the Nominating Committee is not unanimously adopted, the Tellers of Election shall distribute ballots among the members, at once, unless the election is postponed as covered by By-Law No. 14. In either case poll may be opened outside the meeting room in some adjacent and convenient place. If there is no objection, one ballot may be cast for those nominated by the committee.

16. (SECTION 44.) When the appointment of a chairman is not included in the appointment of a committee, the latter shall elect their own chairman.

17. (SECTION 36.) The Secretary shall be in charge of the membership lists. He shall also be in charge of all other property of the Institute not distinctly pertaining to the Treasurer's work.

18. (SECTION 37.) The annual report of the Treasurer shall be embodied in the financial report of the Directors.

19. (SECTION 37.) Neither the Treasurer nor any other officer of the Institute shall pay out money except upon bills approved by the President and a member of the Finance Committee.

20. (SECTION 37.) The Treasurer shall furnish a bond for the faithful performance of his duties to such amount as the Finance Committee may require, such bond to be procured from an incorporated guarantee company at the expense of the Institute.

21. (SECTION 39.) The President, subject to subsequent approval by the Directors, may, in his discretion, appoint a member or members of the Institute to represent it at meetings of Associations of kindred aim or at public functions. Such

delegates should be designated as "Honorary Vice-Presidents," and their duties shall terminate with the occasion for which they are appointed.

22. (Section 39.) Not later than six months prior to each annual meeting of the Institute, the Directors shall appoint an Arrangement Committee to have charge of all the details connected with the annual meeting, except only as to papers.

23. At the opening of the first session, following the election of officers, the President shall appoint a committee of three to recommend the place to be designated by the Institute for the next annual meeting.

24. (Section 55.) Upon receipt of official notice from any district or state gas, or gas and electric association, of a desire to affiliate with the Institute and comply with the provisions of Section 55 of the Constitution, the Directors shall authorize the President and Secretary to execute an agreement with such district association. Upon execution of such agreement, the person designated by the district association as its representative on the Board of Directors, will be recognized as a member of such board to continue in office until his successor is appointed by the district association; or until the agreement is cancelled.

25. (Section 57.) Amendments of, or additions to, the By-Laws may be adopted by the Directors by a unanimous vote at any meeting. When objection is made, two weeks' notice and copy of the proposed changes shall be sent to each Director. At any meeting subsequent to such notice, a two-thirds vote will be sufficient for adoption.

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SMITH, GEORGE PERRY, JR.
Superintendent, Missoula Gas Company, Box 383, Missoula, Montana.

STEVENS, CHARLES H.
Proprietor, Memphis Meter Repair Shop, 299 High Street, Memphis, Tennessee.

STILWELL, JOHN.
Engineering Department, Consolidated Gas Company of New York, 4 Irving Place, New York, New York.

STULL, C. RODMAN.
Engineer, Philadelphia Suburban Gas & Electric Company, Coatesville, Pennsylvania.

TAYLOR, ALLYN C.
Care of Harrisburg Gas Company, Harrisburg, Pennsylvania.

THORN, FRED G., JR.
Chief Draftsman, Manufacturing Department, United Gas Improvement Company, 24 North Twenty-second Street, Philadelphia, Pennsylvania.

TINSMAN, E. H.
Chief Clerk, Clearing House, Laclede Gas Light Company, 716 Locust Street, St. Louis, Missouri.

TOLMAN, WILLIAM NICHOLAS.
Civil Engineer with United Gas Improvement Company, 1723 Columbia Avenue, Philadelphia, Pennsylvania.

TOZER, HENRY.
Foreman, Street Mains, Westchester Lighting Company, 11 New Street, White Plains, New York.

TURNER, CHARLES ALEXANDER.
Assistant Main and Service Foreman, Philadelphia Gas Works, 2128 Erie Avenue, Philadelphia, Pennsylvania.

VITTINGHOFF, HANS VON.
Superintendent, Haverhill Gas Light Company, Haverhill, Massachusetts.

VON STARZENSKI, V.
Engineer, Mohawk Gas Company, Schenectady, New York.

WAGNER, EDWIN.
Care of Massillon Electric & Gas Company, Massillon, Ohio.

WALDRON, CHARLES, JR.
Kingston Gas & Electric Company, 608 Broadway, Kingston, New York.

WARNER, CHARLES PIERIE.
Cadet Engineer, Syracuse Lighting Company, Syracuse, New York.

WARNICK, JOHN H.
Assistant Superintendent Works, Omaha Gas Company, Omaha, Nebraska.

WELLMAN, HOLLEY G.
Manager, Retort Coke Oven Company, 1952 East 83d Street, Cleveland, Ohio.

WILLIAMS, THOMAS G.
Spring Garden District, Philadelphia Gas Works, United Gas Improvement Company, 5643 Ridge Avenue, Philadelphia, Pennsylvania.

WILLIS, CHARLES M.
Care of Brooklyn Union Gas Company, Kent Avenue and Cross Street, Brooklyn, New York.

WILSON, WARD.
Foreman of Distribution, Easton Gas Light Company, 914 Jackson Street, Easton, Pennsylvania.

WUEST, HENRY A.
Chief Clerk, Brooklyn Union Gas Company, foot of North 12th Street, Brooklyn, New York.

ZOOK, SAMUEL, KURTZ.
Engineer, Bergen Division, Gas Department, Public Service Gas Company, 114 Main Street, Hackensack, New Jersey.

Total Junior Members 106

SUMMARY.

Honorary	3
Active	1005
Associate	234
Junior	106
	1348

MEMBERS OF THE AMERICAN GAS INSTITUTE ARRANGED GEOGRAPHICALLY.

Alabama

Bessemer	J. H. Maxon.
Birmingham	A. H. Ford.
	William B. Miller.
	J. M. Ritson.
	Keating Lewis Simons.
Ensley	A. F. Hilleke.
Mobile	Albert F. Kersting.
Montgomery	L. A. Docteur.
	Chas. E. White.

Arkansas

Pine Bluff	B. C. Fowles.
	C. Bert Murdock.

California

Jackson	B. E. Letang.
Los Angeles	William Bauerhyte.
	Jos. M. Berkley.
	Henry W. Burkhart.
	W. B. Cline.
	William J. Dorr.
	Charles P. Houghton.
	Frederick Charles Millard.
	C. S. Vance.
Pasadena	C. W. Koiner.
San Francisco	John A. Britton.
	Edward C. Jones.
	D. E. Keppelman.
	F. V. T. Lee.
	John Martin.
	C. O. G. Miller.
	Sam. L. Napthaly.
Stockton	Henry Eastland Adams.
Upland	Isaac C. Baxter.

Colorado

Canon City	William Bailey.
Colorado Springs	Ira Abbott Miller.
	Geo. B. Tripp.
Denver	John T. Brady.
	C. K. Durbin.
	R. Garland Gentry.
	R. G. Griswold.
	J. R. Hunting.
	M. E. Malone.
	E. W. Schaaf.
	Clare N. Stannard.
	A. F. Traver.
	Charles H. Williams.
Pueblo	Harry D. Frueauff.

Connecticut

Bridgeport	Chas. M. Gerdenier.
	Geo. W. Roberts.
	H. H. Sprague.
Derby	Chas. H. Nettleton.
	George H. Scranton.
Hartford	H. L. Barnes.
	B. Loomis.
	B. W. Perkins.
Meriden	Charles A. Learned.
Milford	William Reeves.
New Haven	J. Arnold Norcross.
	F. C. Sherman.
	Robert E. Wyant.
New London	Alex. J. Campbell.
Rockville	William Morgan Lewis.
Stamford	G. B. Leland.
	Henry J. Warren.
	John A. Waters.
Torrington	Frank M. Travis.
Waterbury	John D. Alden.
	D. L. Summey.
	E. H. Williams.
Winsted	Rufus E. Holmes.

Delaware

Wilmington	R. H. Lawlor.
	Harry S. Schutt.

District of Columbia

Washington	C. Clay Bayly.
	Thomas J. Fisher.
	William F. Hart.
	Thomas F. Holden.
	James S. McIlhenny.
	Robert L. Middleton.

Florida

Jacksonville	Clarence S. Hammatt.
	Harry B. Hoyt.
Ocala	Chas. W. Hunter.
Pensacola	Charles F. Zeek.
St. Augustine	Dan Fitzpatrick.
	C. L. Lyon.
	George Old.

Georgia

Atlanta	P. S. Arkwright.
	Richard C. Congdon.
	F. B. Crowell.
	A. D. Whittaker.
Columbus	MacDougald Dexter.
Macon	G. H. Priest.
	J. J. Cagney.
Rome	James Ferrier.
Savannah	J. L. Cabell.
	John W. Golden.

Illinois

Aurora	I. C. Copley.
	F. M. James.
	B. O'Malley.
	Henry L. Rice.
	R. N. Strohn.
Belleville	Harry B. Kircher.
Bloomington	William F. Clausen.
	Edw. L. Pearsall.
Blue Island	Andrew McIntyre.
Cairo	R. A. McLaughlin.
Chicago	Wm. H. Allen, Jr.
	Knowlton L. Ames.
	C. F. Asendorf.
	Wm. A. Baehr.
	C. Kemble Baldwin.
	Wm. F. Barrett.

Illinois—(*Continued*)

Chicago	Wm. I. Battin.
	Thomas R. Beebe.
	A. Bement.
	R. W. Bingham.
	Wm. G. Bowman.
	E. E. Brownell.
	John C. Buckley.
	F. S. Carnes.
	Alfred A. Chichester.
	John C. D. Clark.
	Mathias Connors.
	Edward G. Cowdery.
	James E. Davies.
	R. N. Davis.
	Rufus C. Dawes.
	C. L. Day.
	Edward A. Dieterle.
	Alfred B. Eaton.
	L. B. Elliott.
	F. J. Ely.
	Ralph Esau.
	John H. Eustace.
	Charles H. Evans.
	Albert L. Farr.
	Russell S. Feurtado.
	George P. Gilman, Jr.
	John Ginley.
	Alfred H. Gross.
	H. D. Harper.
	R. B. Harper.
	A. S. Harrington.
	William G. Henry.
	Homer T. Hirst, Jr.
	Jesse B. Hirst.
	H. R. Hunt.
	Ernest Jacobson.
	William B. Jackson.
	Benjamin J. Kellum.
	Wm. J. Knapp.
	J. W. Lawlor.
	Henry I. Lea.
	Mark Leavenworth.
	Charles R. Lindsay, Jr.

Illinois—(*Continued*)

Chicago	F. E. Luther.
	N. A. McClary.
	G. W. McKee.
	Joseph C. Markley.
	William P. Martin.
	Frank E. May.
	J. E. J. Mayer.
	Charles W. Melcher.
	Wensel Morava.
	Thomas N. Mordue.
	John M. Morehead.
	R. L. Morley.
	Edward E. Morrell.
	Manning A. Norland.
	George G. Olmstead.
	Otto E. Osthoff.
	W. J. Paleske.
	Henry Peters.
	L. R. Phillips.
	Edward G. Pratt.
	Henry Pratt.
	Theo. V. Purcell.
	James A. Rafferty.
	D. G. Ramsay.
	Irwin Rew.
	S. A. Reinhard.
	Rudolph Schenck.
	C. C. Schiller.
	E. E. Sidenstick.
	W. D. Sweetman.
	Charles E. Ummach.
	F. B. Wheeler.
	Lyman A. Wiley.
	John Williamson.
	Richard Williamson.
	William Wilson.
	Herman Zitzewitz.
Chicago Heights	W. F. Booth.
Decatur	John L. Busch.
	Robert Mueller.
DeKalb	E. S. Davidson.
East St. Louis	Charles H. Quackenbush.
Elgin	Robert F. Fitz.
	C. B. Strohn.

Illinois—(*Continued*)

Evanston	R. J. Jenks.
Freeport	Z. T. F. Runner.
	F. C. Weber.
Galena	J. B. Howard.
Joliet	William E. Hartman.
	Heinrich Koppers.
	Thomas Salt.
	H. G. Stillson.
Kankakee	F. E. Newberry.
	F. A. Willard.
Kewanee	Elmer W. Smith.
La Salle	H. E. Chubbuck.
Macomb	F. S. Armstrong.
North Chicago	J. A. Bower.
Oak Park	C. L. Anson.
	Charles W. Bradley.
	H. H. Clark.
	Mathias Britsch.
	Henry D. Schall.
	E. J. H. Wright.
Peoria	E. W. Eustace.
	D. G. Fisher.
	F. H. Foster.
	W. H. Thomson, Jr.
Quincy	Harry O. Channon.
	William Steinwedell.
Rockford	A. W. Kendall.
	C. H. Page, Jr.
	J. F. Parker.
	George D. Roper.
	Henry S. Whipple.
	W. A. Wilson.
Springfield	W. Partridge.
	Emil G. Schmidt.
South Chicago	W. H. Allen, Jr.
Sterling	Elmer Crawford.
Waukegan	H. T. Crawford.
	George F. Goodnow.

Indiana

Anderson	M. G. Reynolds.
	W. R. Wones.
Columbus	C. M. Keller.

Indiana—(*Continued*)

Connersville	George C. Hicks, Jr.
	E. D. Johnston.
	John T. Wilkin.
Crawfordsville	J. N. Dickerson.
Fort Wayne	D. N. Beers.
	A. D. Cressler.
	Alfred M. Cressler.
	George H. Cressler.
	Kerr Murray Cressler.
	Fred W. Freese.
	Olaf N. Guldlin.
	G. Max Hofmann.
	Lothar Hofmann.
	S. E. Mulholland.
	Thomas W. Stone.
	Orrell O. Thwing.
Franklin	J. S. Dales, Jr.
Gary	Leonard Fitzgerald.
Goshen	G. C. Atkinson.
Hammond	A. S. Graham.
Indianapolis	Philmer Eves.
	Carl H. Graf.
	H. L. Olds.
	Henry Rochat.
	George Summers.
Lafayette	S. T. Murdock.
	William Wallace.
	T. Wishart.
Michigan City	G. W. Briggs.
	S. W. Forder.
Muncie	J. E. Colvin.
New Albany	James W. Dunbar.
Peru	George M. Dolley.
	W. V. Spinning.
South Bend	Edw. B. Myers.
	Benj. S. Walters.
	J. H. Warnick.
Terre Haute	Alfred S. Cooke.

Iowa

Burlington	Edward D. Clary.
Cedar Rapids	Glenn M. Averill.
	Thomas Suchomel.
	E. G. Weisgerber.

Iowa—(*Continued*)

Charles City	R. K. Runner.
Clinton	Thomas Crawford.
Council Bluffs	A. L. English.
Davenport	Harold V. Patterson.
	Joseph F. Porter.
Des Moines	Jansen Haines.
	E. H. Martin.
	G. I. Vincent.
Dubuque	George McLean.
Eagle Grove	J. A. Innes.
Fort Dodge	R. M. Parker.
Fort Madison	H. H. Wilson.
Iowa City	George S. Carson.
Le Mars	O. H. Hinds.
Muscatine	Edw. M. Walker.
Oskaloosa	Campbell W. Fair.
	J. F. Griffin.
Ottumwa	David S. Milne.
Sioux City	Wm. J. Bertke.
	Leonard L. Kellogg.
Waterloo	Austin Burt.
	I. C. Elston, Jr.

Kansas

Cherryvale	John C. Dods.
Fort Scott	Freeman Drake Martin.
Independence	A. B. Macbeth.
	William McNair Welsh.
Kansas City	W. H. McKenzie.
Leavenworth	Edward S. Springer.
Topeka	George J. Swan.
	L. G. Treleaven.

Kentucky

Louisville	A. H. Barrett.
	Frank Huber.
	J. J. Humphreys.
	Donald McDonald.
	F. M. Sackett.
	Harry R. Swann.
Richmond	Ira C. Covert.
	J. R. Reyburn.
Paducah	Benj. A. Dougherty.

Louisiana.

Houma	I. N. Knapp.
New Orleans	H. M. Harriman.
	Thomas David Miller.
	Richmond E. Slade.

Maine

Bangor	Vernon K. Gould.
Portland	Eugene H. Yorke.

Maryland

Baltimore	George Beadenkopf.
	E. E. Borst.
	Howard Bruce.
	C. H. Claiborne.
	Charles M. Cohn.
	Charles H. Dickey.
	Edmund S. Dickey.
	E. Bartlett Hayward.
	E. S. Newbold.
	L. Irving Pollitt.
	Louis N. Rancke.
	Edward L. Rieha.
	R. S. Scott.
	Fred H. Wagner.
	Charles White.
Cumberland	John J. Power.
Frederick	J. H. Enright.

Massachusetts

Attleboro	William J. Luther.
Beverly	C. R. Prichard.
Boston	W. B. Calkins.
	Alfred Clarke.
	Dwight T. Cortis.
	F. N. Eisenman.
	John A. Gould.
	Robert Grant.
	M. S. Greenough.
	Chas. W. Hunter.
	L. B. Johns.
	A. D. Little.
	W. E. McKay.
	Arthur E. Norton.
	Harry A. Norton.
	Theo. H. Piser.

Massachusetts—(*Continued*)

Boston	J. L. Richards.
	Frederick P. Royce.
	F. K. Wells.
	William Austin Wood.
	Edgar N. Wrightington.
Cambridge	Albert M. Barnes.
	J. P. Kennedy.
Charleston	Samuel J. Fowler.
East Boston	N. W. Gifford.
Everett	John F. Wing.
Fall River	V. E. Bird.
	Joseph E. Nute.
Fitchburg	William L. Walker.
Gloucester	John A. Coffin.
Haverhill	Charles W. Morse.
	H. Von Vittinghoff.
Holyoke	William H. Snow.
Lawrence	C. J. R. Humphreys.
	Fred H. Sargent.
	H. G. Taylor.
Lowell	R. Buckminster.
	C. W. Hinman.
Lynn	Charles F. Prichard.
Malden	C. E. Paige.
	Albert B. Tenney.
New Bedford	Charles H. Gifford.
	Robert Lindsay.
	George R. Stetson.
Newton	R. A. Fancy.
	Waldo A. Learned.
Pittsfield	Harry C. Crafts.
Springfield	Benjamin P. Bill.
	Herman Burgi.
	Charles H. Tenney.
Wakefield	Albert B. Morton.
Webster	H. S. Shaw.
Worcester	Charles Dudley Lamson.

Michigan

Ann Arbor	Henry W. Douglas.
	Alfred H. White.
Battle Creek	F. K. Berry.
	D. N. Frazer.
Charlotte	Edward J. Elles.

Michigan—(*Continued*)

Detroit	William Taft Barbour.
	W. H. Barthold.
	J. W. Batten.
	Warren S. Blauvelt.
	D. F. Buritt.
	Irvin Butterworth.
	V. F. Dewey.
	J. G. Diffenderfer.
	G. B. Dobbin.
	Alex. Dow.
	W. B. Fairbairn.
	William H. Frost.
	Jules G. Hoffman.
	E. F. Hyland.
	Frank K. Lane.
	Nathan G. Leakey.
	Alfred G. Lloyd.
	Ernest F. Lloyd.
	James T. Lynn.
	J. N. McCallum.
	George Osius.
	Charles S. Ritter
	C. A. Schwarm.
	R. Shacklette.
	A. F. Shattuck.
	Otis A. Sinsel.
	Edwin G. Van Wie.
	A. L. Wilkinson.
	L. B. Young.
Flint	H. M. Eaton.
	Edw. J. Gutsche.
Grand Rapids	Glenn. R. Chamberlain.
	Ralph S. Child.
	Edward M. Deane.
	Frank T. Hulswit.
	Richard Schaddelee.
	John Hellen.
	B. O. Tippy.
	T. J. Weber.
Hancock	Max. H. Cutcheon.
Holland City	Howard Bixby.
Ironwood	E. L. Lambert.
Ishpeming	William J. McCorkindale.

Michigan—(*Continued*)

Jackson	R. B. Laraway.
Kalamazoo	Walter M. Blinks.
	Frank W. Blowers.
	Charles T. Chisholm.
	H. S. Humphrey.
	J. J. Knight.
	Wm. Thompson.
	A. L. Zwisler.
Lansing	D. K. Crighton.
Laurium	C. C. Sloan.
Marshall	Carroll Collins.
Marquette	H. J. Waterbury.
Muskegon	John T. Young.
Port Huron	J. C. Sloan.

Minnesota

Albert Lea	Ludwig Kemper.
Duluth	C. W. Andrews.
Faribault	B. W. Cowperthwait.
Mankato	Robert. E. Brown.
Minneapolis	F. C. Bestor.
	F. W. Little.
	Frederick C. Shepard.
St. Paul	John P. Crowley.
	Paul Doty.
	V. L. Elbert.
	Bert. F. Pelton.
	George Steinwedell.
	H. B. Stiles.
West Duluth	W. H. Wright.
Winona	L. C. Graham.

Mississippi

Jackson	James T. Pullen.
Vicksburg	John J. Gannon.

Missouri

Boonville	W. E. Sombart.
Brookfield.	Louis D. Kelsey.
Cape Girardeau	Clarence E. Wakeman.
Independence	Robert S. Miller.
Jefferson City	P. A. Bertrand.
Joplin	B. J. Crahan.

Missouri—(*Continued*)

Kansas City	E. L. Brundrett.
	Byron E. Chollar.
	E. W. Hammond.
	A. Hurlburt.
	Miss Anna Virginia Miller.
	F. F. Schauer.
	John M. Scott.
	M. M. Sweetman.
	William M. Wood.
St. Joseph	Kerr M. Mitchell.
St. Louis	August Court.
	Augustin J. Daly.
	John Dell.
	William S. Dodd.
	A. C. Einstein.
	Geo. G. Evans.
	L. C. Hamlink.
	J. E. Hillemeyer.
	C. L. Holman.
	W. A. Lockwood.
	Charles A. Magee.
	P. S. Marquis.
	Alten S. Miller.
	Roger W. Polk.
	W. S. Reger.
	Daniel R. Russell.
	Robert Seeger.
	E. H. Tinsman.
	Jacob D. Von Maur.
	W. H. Whitton.
	Leigh Wickham.
Springfield	W. A. Bixby.

Montana

Helena	G. A. Strain.
Missoula	G. P. Smith, Jr.

Nebraska

Lincoln	B. C. Adams.
Omaha	G. W. Clabaugh.
	John C. Grey.
	J. A. Perry.

New Hampshire

Concord	Henry K. Morrison.
Keene	Wm. A. Richards.
	G. M. Rossman.
Manchester	Walter G. Africa.
	Alex. H. Scott.
Nashua	Walter F. Norton.

New Jersey

Atlantic City	F. B. Aldrich.
	S. Bradley.
	F. R. Hutchinson.
	J. E. Morgan.
	John P. Tompkins.
Bayonne	H. A. Wheeler.
Camden	W. H. Allen
	John J. Burleigh.
	George W. Curtis.
	James N Downey.
	Harry Ellis.
	George Hobdell.
	E. A. Moore.
Cape May	O. A. Merchant, Jr.
Dover	S. H. Ely.
Elizabeth	Roger Crilley.
	Francis Engel.
Englewood	W. E. Reynolds.
Glassboro	Charles W. Hoy.
Gloucester City	Thomas J. Litle, Jr.
	Norman Macbeth.
	Townsend Stites.
	C. W. Wardell.
	M. C. Whittaker.
Hackensack	E. C. Roberts.
	S. K. Zook.
Hoboken	John Cabot.
	W. Greacen, Jr.
Jersey City	Joseph B. Ames.
	James Ashworth.
	West Bissell.
	David R. Daly.
	E. J. Donahue.
	H. H. Ferris.
	J. P. Henofer.
	F. W. Schmidt.

New Jersey—(*Continued*)

Long Branch	E. E. Eysenbach.
	D. W. Flowers.
Merchantville	J. A. Callenbach.
Montclair	J. P. Zingg.
Morristown	Robert D. Foote.
	William W. Wright.
Newark	William S. Barker.
	John H. Braine.
	William H. Chadwell.
	Walter L. Chewning.
	John A. Clark, Jr.
	P. T. Dashiell.
	J. S. Dehart, Jr.
	James P. Dusenberry.
	E. H. Earnshaw.
	W. M. Halsey.
	J. P. Hanlan.
	Thomas N. McCarter.
	Hugh K. MacDougall.
	J. G. O'Keeffe.
	W. H. Pettes.
	Geo. J. Roberts.
	Chas. J. Roeser.
	J. McClellan Rogers.
	Alexander H. Strecker.
	Adolph Frederick Wehner.
	Robert K. Wehner.
	H. D. Whitcomb, Jr.
	Percy S. Young.
	R. R. Young.
New Brunswick	W. F. Thomas.
Passaic	J. F. Kilgour.
	C. A. Stelling.
Paterson	John Bimson, Jr.
	Theo. Bunker.
	Jas. M. Lane.
	W. H. Rogers.
	William L. Williams.
Perth Amboy	H. Foersterling.
	A. F. Reitmeyer.
Plainfield	W. R. Causebrook.
	Thomas Melick.
	D. P. Skellenger.

New Jersey—(*Continued*)

Rutherford	Addison Ely.
South Amboy	William E. Bedle.
Summit	M. S. Sherwood.
Toms River	B. H. Spangenberg.
Trenton	Charles G. Cook.
	Frank D. Moses.
West Hoboken	James Kennedy.

New York

Albany	D. F. Brown.
	S. P. Cobb.
	F. S. Dunn.
	John E. Gaitley.
	John J. Garrison.
	E. P. Gavit.
	Donald McDonald.
	F. McDonald.
	R. E. Sard.
	R. H. Smith.
Amsterdam	W. H. Cooper.
Astoria, L. I.	H. S. Hudson.
	N. J. Sperling.
	Peter Young.
Bay Shore	F. S. North.
Bay Side	Charles Boone.
Binghamton	Charles W. Bennett.
	Robert W. Manier.
Brooklyn	Robert Wilder Bush.
	Edward J. Byrne.
	Edward Louis Byrne.
	Thomas E. Byrne.
	James H. Jourdan.
	John D. Logan.
	E. H. Mathews.
	A. F. Staniford.
	L. S. Stiles.
	Chas. M. Willis.
	H. A. Wuest.
	Jos. E. Aue.
Buffalo	Lucius S. Bigelow.
	H. C. Palmer.
	Walter W. Richardson.
	William S. Riselay.
Canandaigua	V. A. Miller.

New York—(*Continued*)

Cohoes	W. P. Parsons.
Coney Island	G. H. Woodall.
Far Rockaway	L. A. Howland.
	Carlton Macy.
	Louis B. Sharp.
Flushing	M. H. Spear.
	Ed. J. Sullivan.
	W. H. Sullivan.
Geneva	E. H. Palmer.
Gloversville	H. B. Bryans.
	L. D. Spragle.
	W. H. Taylor.
Hempstead	S. K. Campbell.
Ithaca	T. W. Summers.
Kingston	Franklin Tobey, Jr.
	Chas. Waldron, Jr.
Little Falls	Henry P. Collins.
Long Island City	C. Cassels Atwood.
	W. W. Burden.
	Clifford S. Fox.
	W. F. Lawrence.
	M. E. Mueller.
	Crist H. Stevick.
	C. G. M. Thomas.
Mt. Vernon	Chas. F. Bryant.
	William J. Clark.
	E. B. Davis.
	J. H. Green.
	Robert James Jennings.
	Alfred M. Keene.
	R. M. Kellogg.
	George T. Macbeth.
	F. M. Roberts.
	W. L. Secord.
	H. Sherwood.
Newburgh	A. R. Beal.
	William R. Beal.
	B. J. MacDonald.
	L. H. Scherck.
New York City	H. C. Abell.
	Frederick P. Addicks.
	Walter R. Addicks.
	H. W. Alrich.
	J. Charles Andrews.

New York—(*Continued*)

New York City	C. G. Atwater.
	C. T. Ayres.
	Anastasio C. M. Azoy.
	T. S. Barlow.
	F. R. Barnitz.
	William E. Barrett.
	Frederick C. Bates.
	Albert B. Beadle.
	Edward A. Behringer.
	E. W. Bell.
	Fred L. Bradley.
	William H. Bradley.
	James C. Brady.
	Ernest C. Brown.
	H. M. Brundage.
	Milan R. Bump.
	Sterling H. Bunnell.
	J. F. Butler.
	Elbert P. Callender.
	H. E. Carpenter. ,
	Robert A. Carter.
	Robert A. Carter, Jr.
	Chas. F. Chandler.
	E. S. Chapin.
	Frank P. Cheesman.
	B. C. Cobb.
	William M. Crane.
	Philip Gross.
	William DeFreitas.
	J. Alfred Dixon.
	R. M. Dixon.
	George W. Doane.
	Henry L. Doherty.
	Parr H. Dole.
	Chas. Dougherty.
	Wm. Dougherty.
	F. J. Down.
	Philip Dunne.
	W. M. Eaton.
	W. K. Eavenson.
	A. B. Eilbeck.
	Arthur L. Elliott.
	Wm. M. Flook.
	Frederick W. Floyd.

New York—(*Continued*)

New York City	James R. Floyd, Jr.
	O. H. Fogg.
	Alfred E. Forstall.
	Gilbert Franklyn.
	Frank W. Frueauff.
	William H. Gardiner.
	L. D. Gardner.
	Lewis B. Gawtry.
	C. J. Gefvert.
	Patrick Goodman.
	W. R. Goudy.
	Malcolm M. Graham.
	J. A. Haefelin.
	F. E. Hague.
	A. H. Hall.
	W. K. Harrington.
	G. E. Harris.
	F. S. Hastings.
	W. J. Hawthorn.
	Sterling F. Hayward.
	Geo. S. Hessenbruch.
	C. M. Higgins.
	Chas. H. Hodges.
	John W. Hornsey.
	David Leavitt Hough.
	William Greely Hoyt.
	Alexander C. Humphreys.
	Jas. F. Hunter.
	Charles L. Inslee.
	Charles W. Isbell.
	C. N. Jeliffe.
	Mervyn E. Johnston.
	P. R. Jones.
	Edward R. Jourdan.
	Julius Kahn.
	C. F. Keegan.
	R. C. Kellogg.
	James S. Kennedy.
	I. C. Kingsbury.
	I. Clayton Kingsbury.
	M. Kirchberger.
	W. J. Knothe.
	V. R. Lansingh.

New York—(*Continued*)

New York City .....Alanson P. Lathrop.
Albert Lauber.
E. C. Leiman.
C. F. Leonard.
Robert O. Luqueer.
Joseph Lush.
E. A. Lyon.
J. M. McCarthy.
J. W. McClellan.
W. N. McIlravy.
H. B. McLean.
Emerson McMillin.
Marion McMillin.
George MacDonald.
W. L. MacIntosh.
J. H. Mansfield.
William D. Marks.
G. P. Morrow.
John A. Mason.
F. J. Mayer.
J. Alex. Mayers.
Jos. P. Maxwell.
G. W. Mead.
Robert C. Miller.
Preston S. Millar.
William N. Milsted.
Clarence P. Morrell.
W. Cullen Morris.
Louis F. Musil.
E. A. Nelson.
John F. Nelson.
Edwin North.
Harry T. Owens.
George W. Parker.
H. L. Peden.
Irwin W. Peffly.
J. H. Perkins.
Frank J. Petura.
A. G. Pickens.
C. Pilz.
Arthur Postley.
C. C. Potter.
Daniel J. Prendergast.

New York—(*Continued*)

New York City	Charles Raabe.
	George G. Ramsdell.
	William W. Randolph.
	Wm. T. Rasch.
	Albert Riblet.
	P. F. Reichelm.
	Chas. D. Robison.
	Albert Rosenthal.
	Robert R. Rust.
	Thomas V. Rutter.
	Eugene Y. Sayer.
	F. Schniewind.
	Thomas Scofield.
	Marvin Shiebler.
	Colin C. Simpson.
	C. C. Simpson, Jr.
	Albert Sommer.
	John Stilwell.
	William Strobridge.
	Charles F. Terhune.
	Richard Henry Thomas.
	Lucien P. F. Tull.
	H. L. Underhill.
	A. Van den Driessche
	George H. Warner.
	Albert J. Weber.
	Louis H. Werner.
	E. C. White.
	Benjamin Whitely.
	Charles A. Whittier.
	George Williams.
	Jas. E. Wilmot.
	Frank Wilshire.
	G. J. Wilson.
	Edwin E. Witherby.
	S. E. Wolff.
	George E. Woods.
	Arthur L. Woollen.
Niagara Falls	Albert H. Merritt.
Ossining	H. W. Terry, Jr.
Oswego	R. F. Whitney.
Owego	A. P. Storrs.
	Chas. P. Storrs.

New York—(*Continued*)

Penn Yan	Wm. T. Morris.
Plattsburg	George M. Cole.
Port Chester	Joseph P. Kane.
	F. M. Mills.
Poughkeepsie	E. V. Anderson.
	T. R. Beal.
	James M. Hadden.
Rochester	J. C. Collins.
	James B. Eaton.
	Joseph P. Haftenkamp.
	Frank Hellen.
	James T. Hutchings.
	Herman Russell.
	E. C. Scobell.
	Robert M. Searle.
	C. A. Tucker.
Rome	Roy Albright Field.
Rosebank P. O.	F. W. Sargeant.
Rye	J. K. Crowell.
Saratoga Springs	Patrick F. Roohan.
Schenectady	George Fullerton.
	M. W. Offutt.
	A. J. Smith.
	Howard L. Starr.
	V. vonStarzenski.
Stapleton	E. B. Fielis.
	H. M. Holmes.
	H. Muller, Jr.
	William J. Welsh.
Syracuse	James C. DeLong.
	Arthur D. Dudley.
	Howard Hoffman.
	Ernest Johnston.
	S. C. Singer.
	C. P. Warner.
	Edwin C. Witherby.
Tarrytown	John A. Neth.
Troy	James H. Caldwell.
Utica	William J. Cahill.
	Herbert Gilmore Johnson.
Warsaw	W. E. Hemenway.
Watertown	John B. Taylor.
Waverly	F. A. Gillette.

New York—(*Continued*)

West Chester	Eugene H. Rosenquest.
White Plains	E. S. Martin.
	Henry Tozer.
Yonkers	E. O. Baxter.
	H. B. Kellogg.
	A. M. Knapp.
	Charles Otten, Jr.

North Carolina

Asheville	H. W. Plummer.
Durham	R. W. Miller.
Greensboro	E. C. Deal.
Winston-Salem	B. N. Sullivan.

North Dakota

Fargo	Samuel Kahn.
Grand Forks	W. J. Murphy.

Ohio

Alliance	D. W. Low.
Ashtabula	Frederick W. Stone.
	Joseph H. Willsey.
Bucyrus	H. O. Dutter.
Canton	Joseph L. Loichot.
	Spencer S. Weart.
Chillicothe	Frederick A. Stacey.
Cincinnati	A. M. Dolph.
	C. H. Fischer.
	John Franklin.
	F. L. Garrison
	P. H. Gibbons.
	Edward W. Hake.
	Norman G. Kenan.
	E. E. Miller.
	William A. Miller.
	Charles H. Printz.
	W. H. Schmidlapp.
	Andrew J. Stacey.
	James E. Stacey.
Cleveland	Charles S. Beardslee.
	Martin B. Daly.
	A. V. Ellis.
	H. C. Fritz.
	C. C. Gartland.

Ohio—(*Continued*)

Cleveland	A. L. Gassett.
	Edward P. Hyde.
	Gustavus A. Hyde.
	B. F. Klein.
	William H. Knight.
	Virgil G. Marani.
	Melvin Pattison.
	A. T. Perry.
	Pierre Plantinga.
	Arthur M. Smith.
	Carl Steinwedell.
	W. E. Steinwedell.
	W. W. Stephens.
	Frank E. Taplin.
	H. J. Trenkamp.
	Daniel R. Warmington.
	George H. Warmington.
	J. G. Way.
	Holley G. Wellman.
	George W. York.
Columbus	J. M. Garard.
	Alan Leamy.
	William R. Powell.
	Henry D. Turney.
Dayton	Edward H. Light.
	George Light.
	W. W. Price.
	Frank M. Tait.
Defiance	David Elder.
Delaware	Thomas Clive Jones.
Hamilton	Lazard Kahn.
Lima	S. E. Mulholland.
	John D. S. Neely.
	M. L. Neely.
Lorain	Daniel Roesch.
Mansfield	William C. Hedges.
	C. W. Upson.
Marion	George Whysall.
Massilon	Robert R. Choate.
	Edwin Wagner.
Middleton	G. N. Clapp.
Newark	Melville Gillett.
Portsmouth	John R. Lynn.

Ohio—(*Continued*)

Toledo	J. R. Cunningham.
	Jos. E. Lockwood.
Warren	George Daugherty.
	John C. Gorton.
Youngstown	Fred S. Coombs.

Oklahoma

Muskogee	Henry H. White.

Pennsylvania

Allentown	John A. Frick.
Altoona	G. K. Dustin.
	Harry C. Ross.
Ardmore	George B. Bains, 3d.
	John L. Mather.
Bethlehem	W. F. Brodnax.
	James W. Murdock.
Bolivar	N. A. Young.
Bradford	George P. Boothe.
	S. R. Dresser.
	Fred A. Miller.
Carbondale	Chas. L. Rowland.
Catasauqua	G. W. Steele.
Chester	Hugh Carlton Aiken.
	L. D. Huestis.
	A. L. Milligan.
	Charles Wilde.
Coatesville	W. J. Phifer.
	C. R. Stull.
Danville	George W. West.
Darby	Charles J. Fox.
Easton	B. F. Cresson.
	Edwin G. Holzer.
	Ward Wilson.
East Pittsburg	Thomas C. Clifford.
	E. D. Dreyfus.
Erie	Albert MacDonald.
	F. H. Payne.
Fort Washington	William Hobson Vollum.
Greenville	A. C. Hartzell.
Hanover	R. H. Dutton.
	H. D. Gillingham.

Pennsylvania—(*Continued*)

Harrisburg	C. M. Cole.
	A. C. Taylor.
	A. J. Palmer.
	Luther S. Williams.
Irwin	Edwards F. Wilson.
Jenkintown	L. R. Dutton.
Johnston	William H. C. Ramsey.
Lancaster	C. E. Titzel.
Lebanon	W. H. Merritt.
Lewistown	Eugene F. McCabe.
Milton	C. W. Butterworth.
New Eagle	M. W. Butler.
Norristown	Herbert H. Ganser.
Philadelphia	H. C. Adams.
	E. R. Alburger.
	Walter A. Allison.
	F. M. Arthur.
	James Ball.
	Geo. J. Barnes.
	J. C. Bartlett.
	Geo. S. Barrows.
	Henry S. Battin.
	Isaac Battin.
	Walter W. Beaumont.
	C. M. Benedict.
	W. H. Bettle.
	Samuel Taylor Bodine.
	Charles O. Bond.
	Cyrus Borgner.
	Albert M. Boyd.
	Henry R. Cartwright.
	William A. Castor.
	Henry B. Christy.
	Walton Clark.
	W. W. Cole.
	H. W. Coleman.
	David J. Collins.
	E. M. Colquhoun.
	Roger B. Combs.
	H. R. Cook, Jr.
	F. G. Corbus.
	J. W. Crankshaw.
	R. C. Cornish.

Pennsylvania—(*Continued*)

Philadelphia .....G. W. Crawford.
J. A. P. Crisfield.
A. R. Cruse.
G. W. Curran.
Samuel P. Curtis.
R. E. Dallas.
H. W. Davies.
Mark Dean.
Carl A. Dickel.
S. J. Dickey.
William F. Dorner.
James B. Douglass.
W. F. Douthirt.
N. A. Dutton.
W. G. Earnshaw.
Owen B. Evans.
Walton Forstall.
John Fowler.
J. Scott Fowler.
W. B. Franklin.
F. C. Freeman.
Walter H. Fulweiler.
William H. Gartley.
T. Bertram Genay.
Thomas S. Genay.
Thomas L. George.
Francis H. Gilpin.
H. W. Graeff.
Albert Green.
John Gribbel.
H. O. Gross.
Charles F. Hardick.
C. Willing Hare.
G. M. Harrison.
William E. Helme.
G. R. Hemminger.
G. R. Horning.
Abram C. Howard.
J. H. Hubbs.
Thos. H. Jackson.
Robert C. James.
William Kane.
John Bartleman Klumpp.
P. J. Lafore.

Pennsylvania—(*Continued*)

Philadelphia ..... W. P. Lane.
W. W. Levering.
Lewis Lillie.
H. Livingston.
Joseph Lucena.
John McIlhenny.
John D. McIlhenny.
Andrew P. Maloney.
William H. Marshall.
Sidney Mason.
James B. Mingus.
Martin Molony.
F. N. Morton.
Joseph B. Meyers.
Carroll B. Nichols.
Rollin Norris.
Charles M. O'Connell.
C. J. O'Donnell.
T. Brandon Ordish.
Edward Page.
Joseph Smith Parker.
W. F. Pearce.
Joshua Ashe Pearson.
M. F. Perkins.
Rowan P. Perkins.
H. W. Plucker.
Charles J. Ramsburg.
Clarence V. Roberts.
W. T. Robinson.
Edward H. Rodgers.
William L. Rowland.
John M. Rusby.
John M. Ruegenberg.
F. J. Rutledge.
J. Fred Seamon.
Jas. R. Schurtz.
William J. Serrill.
R. K. Severson.
John D. Shattuck.
C. D. Shaw, Jr.
Frederick H. Shelton.
Howard R. Sheppard.
John W. Smith.

Pennsylvania—(*Continued*)

Philadelphia	Charles S. Snyder.
	Henry Steck.
	Jacob W. Stirzel.
	Morris W. Stroud.
	J. Hawley Taussig.
	Richard H. Thomas.
	Paul Thompson.
	Geo. W. Thomson.
	Fred G. Thorn, Jr.
	William Nichols Tolman.
	R. H. Trimble.
	C. A. Turner.
	Carrington Cabell Tutwiler.
	Charles N. Vollum.
	A. V. Wainwright.
	John S. Welch.
	F. V. Westermaier.
	Henry Wharton.
	Thomas G. Williams.
	Edward R. Wood, Jr.
	George B. Wood.
	Stuart Wood.
	Louis N. Yetter.
Pittsburg	George W. Barnes.
	Arthur Booth.
	Alfred P. Brill.
	H. A. Carpenter.
	R. C. Frampton.
	Charles L. Gerould.
	Joseph F. Guffey.
	William H. Hammon.
	F. J. Laird.
	Edw. D. Leland.
	R. S. Lord.
	J C. McDowell.
	Walter L. McCloy.
	G. R. Nutty.
	Willard B. Osborne.
	Roland G. Porter.
	James H. Reed, Jr.
	Edwin Ruud.
	Frank N. Speller.
	Samuel B. Stewart.

Pennsylvania—(*Continued*)

Pittsburg	C. W. Townsend.
	John Young.
	Robert Young.
	R. H. Youngman.
Plymouth	William Anderson.
Pottstown	Herbert G. Williams.
Pottsville	R. C. Morris, Jr.
Reading	John H. Keppelman.
Royersford	John H. Mansur.
Scranton	William McKelvey Marple.
	W. E. Mockett.
	Worthington Scranton.
	E. M. Stack.
Sunbury	George W. Beck.
Westchester	William O. Lamson, Jr.
Williamsport	Ernest H. Davis.
	Wm. R. Rhoades.
York	F. R. Smart, Jr.

Rhode Island

Newport	A. K. Quinn.
Pawtucket	Frederick W. Easton.
	William McGregor.
Providence	George A. Allyn.
	W. C. Buell, Jr.
	Edmund Cathels.
	John W. Ellis.
	Carroll Miller.
	W. H. Price.
Slocums	A. B. Slater.

South Carolina

Charleston	G. H. Waring.
Columbia	S. W. Brown.
	Guy K. Dustin.

South Dakota

Aberdeen	Charles A. Howard.
Mitchell	E. J. Sherwood.
Roseland	Peter N. Smith.
Sioux Falls	Chester N. Chubb.
	S. E. Linton, Jr.
Yankton	C. H. Bell.

Tennessee

Chattanooga	M. Morgans.
Jackson	H. E. Kincaid.
Knoxville	C. C. Durkee.
	Alfred W. Young.
Memphis	Richard Rees.
	Charles H. Stevens.
	L. A. Van Ness.
Nashville	A. B. S. Little.

Texas

Austin	H. M. Moore.
Beaumont	M. T. Walker.
Dallas	C. W. Tippy.
El Paso	Thomas J. Jones.
Galveston	Chas. S. French.
Houston	C. H. Dunbar.
San Antonio	G. H. Cushman.
	M. J. Dewey.
	J. B. Franzini.
	E. B. Henson.
	G. J. Houston.
	L. B. Moorhouse.
	L. H. Onderdonk.
	W. B. Tuttle.

Utah

Salt Lake City	L. L. Cadwallader.
	J. Charles Ross.

Vermont

Burlington	Frank H. Parker.

Virginia

Charlottesville	H. M. Hantzmon.
Danville	Frank Talbot.
Fredericksburg	B. F. Bullock.
Hampton	F. L. Marshall.
Norfolk	Frederic Egner.
	E. C. Hathaway.
	R. J. Marks.
	F. H. Sawyer.
Petersburg	E. C. Pond.
Portsmouth	B. B. Ferguson.
Richmond	William P. Knowles.
Roanoke	E. M. Funkhouser.
	A. G. King.

Washington

Seattle	Charles Russell Collins.
	N. C. Fancher.
	A. F. Mueller.
	Frederick K. Lane.
Spokane	W. A. Bertke.
	A. N. Cantril.
	E. H. Gimper.
	E. G. Pratt, Jr.
	G. J. Houston.
Sulphur Springs	W. S. Dole.
Tacoma	Henry H. Hyde.
	W. A. Leuenberger.
	William W. Seymour.
Vancouver	F. W. Leland.

Wisconsin

Beloit	B. F. Lyons.
	E. D. V. Dickey.
	T. J. Kelley, Jr.
Berlin	Thomas B. Wood.
Eau Claire	David Douglass.
Janesville	I. V. Wortendyke.
Kenosha	Roger N. Kimball.
Madison	C. F. Burgess.
	John Corscot.
	F. L. Cross.
	O. L. Kowalke.
	D. A. Powell.
	Fred M. Richards.
	W. A. Richards.
	Arthur W. Richter.
	John St. John.
Manitowoc	R. S. Douglas.
Marinette	W. R. Putnam.
Milwaukee	John I. Beggs.
	R. B. Brown.
	Fred Bredel.
	Sheldon J. Glass.
	Ewald Haase.
	Henry M. Humphreys.
	W. F. Hyde.
	R. P. Kraft.
	M. N. Latta.
	Bryce McAdam.

Wisconsin—(*Continued*)

Milwaukee	John T. Mason.
	J. C. Shirra.
	L. M. Whitwell.
	A. C. Wilke.
Oshkosh	Sinclair Mainland.
	William Mainland.
	O. G. F. Markhus.
Watertown	P. L. Utley.
Waukesha	H. M. Buck.
Winonah	J. A. Patten.

Territory of Hawaii

Honolulu	Alonzo Gartley.

Belgium

Brussels	T. A. Vander Willigen.

Brazil, South America

Rio de Janeiro	H. B. Harrop.

Canada, Alberta

Calgary	A. I. Payne.

Canada, Ontario

Chatham	P. S. Coate.
Hamilton	William Gibson.
	John Keillor.
	John B. McNary.
Toronto	Frederick Burnett.
	Arthur Hewitt.
	L. L. Merrifield.
	W. H. Pearson.
	W. H. Pearson, Jr.
	Robert Bruce Steward.

Canada, Quebec

Montreal	Howard E. Mann.
	Samuel Skinner.
Quebec	R. A. Wallace.

England

London	F. J. Angell.
	L. D. Carroll.
	Arthur G. Glasgow.
	H. M. Hodson.
	Frederick Thuman.
	John Townsend Westcott.
	Corbet Woodall.
Liverpool	William King.

Germany

Dresden ..... A. E. Boardman.

Japan

Nagoya ..... Sakura Okamoto.
Osaka ..... Chas. P. Cushman.
Tokio ..... Suyekichi Hiramatsu.

Mexico

Guadalajara ..... W. A. Aldrich.

Newfoundland

St. Johns ..... W. H. Rennie.

SUMMARY OF GEOGRAPHICAL DISTRIBUTION.

Alabama	9	North Dakota	2
Arkansas	2	Ohio	73
California	19	Oklahoma	1
Colorado	14	Pennsylvania	221
Connecticut	23	Rhode Island	10
Delaware	2	South Carolina	3
District of Columbia	6	South Dakota	6
Florida	7	Tennessee	8
Georgia	10	Texas	14
Illinois	141	Utah	2
Indiana	41	Vermont	1
Iowa	26	Virginia	13
Kansas	8	Washington	14
Kentucky	9	Wisconsin	38
Louisiana	4	Belgium	1
Maine	2	Brazil	1
Maryland	17	Alberta, Canada	1
Massachusetts	53	Ontario, Canada	10
Michigan	62	Quebec, Canada	3
Minnesota	15	England	8
Mississippi	2	Japan	3
Missouri	38	Newfoundland	1
Montana	2	Mexico	1
Nebraska	4	Germany	1
New Hampshire	6	Territory of Hawaii	1
New Jersey	86		
New York	290		
North Carolina	4	Total	1348

In Memoriam.

MOSES COOMBS
Youngstown, Ohio
Died March 13, 1909

THOMAS J. HAYWARD
Baltimore, Md.
Died October 23, 1909

GEORGE M. WITHERDEN
Philadelphia, Pa.
Died December 15, 1909

JOHN F. KLUG
Pueblo, Col.
Died January 2, 1910

W. B. CLEMENTS
Ossining, N. Y.
Died January 6, 1910

ARTHUR T. AVERILL
Cedar Rapids, Ia.
Died April 10, 1910

JAMES B. McGOWAN
Kansas City, Mo.
Died April 25, 1910

WILLIAM H. SMITH
Philadelphia, Pa.
Died May 16, 1910

O. F. GREIM
Milwaukee, Wis.
Died June 6, 1910

THOMAS O. HORTON
Stapleton, Staten Island, N. Y.
Died June 13, 1910

W. A. STADLEMAN
New York, N. Y.
Died July 6, 1910

MOSES COOMBS.

At the time of his death Mr. Coombs was Superintendent of the Gas Department of the Youngstown (Ohio) Gas and Electric Company. He joined the Ohio Gas Light Association in 1885, and upon the formation of the American Gas Institute joined that as a Charter Member.

THOMAS J. HAYWARD.

Mr. Hayward was born in Baltimore, Md., in 1847. During his active business life he occupied a prominent position in the gas industry. At the time of his death he was President of the Bartlett, Hayward Company of Baltimore, which corporation was the successor to the firm of Bartlett, Hayward & Co., well known since 1880 as constructors of gas holders and gas apparatus.

Mr. Hayward was much esteemed in his native city, taking a prominent part in social and civic matters.

He joined the American Gas Light Association in 1884, and the Ohio Gas Light Association in 1905. He came into the American Gas Institute as a Charter Member in 1906.

GEORGE M. WITHERDEN.

Mr. Witherden was born in England in 1853. During his entire business career he was associated with the meter manufacturing business. He was connected with the American Meter Company for 23 years, with the Metric Metal Works of Erie, Pa., for some time, and for several years with John J. Griffin & Company, in Philadelphia.

Mr. Witherden joined the Western Association in 1892, the Ohio Gas Light Association in 1899 and the American Gas Light Association in 1904, coming into the American Gas Institute as a Charter Member in 1906.

JOHN F. KLUG.

At the time of his death Mr. Klug had recently been appointed Superintendent of the Pueblo Gas and Fuel Company, Pueblo, Col. His former training in the gas business had been with the gas companies at Denver and Knoxville. He joined the American Gas Institute as a Junior Member in 1909.

W. B. CLEMENTS.

At the time of his death Mr. Clements was Treasurer of the Peekskill Lighting and Railroad Company, Ossining, N. Y. Prior to this he had been Auditor of the Westchester Lighting Company, Mt. Vernon, N. Y.

Mr. Clements joined the American Gas Light Association in 1902 and came into the American Gas Institute as a Charter Member.

ARTHUR T. AVERILL.

Mr. Averill was President of the Cedar Rapids Gas Light Company, Cedar Rapids, Ia.

He joined the Western Gas Association in 1905 and came into the American Gas Institute as a Charter Member.

JAMES B. McGOWAN.

Mr. McGowan was connected with the gas business in Kansas City for a number of years. He was General Manager of the Kansas City, Mo. Gas Co. and President of the Wyandotte (Kans.) Gas Co. He joined the American Gas Institute in 1908.

WILLIAM H. SMITH.

At the time of his death Mr. Smith was Superintendent of Distribution for the City Department of the United Gas Improvement Company in Philadelphia. From about 1874 to 1897 he was Superintendent of the gas company at Bayonne, N. J.

Mr. Smith joined the American Gas Light Association in 1891 and came into the American Gas Institute as a Charter Member.

O. F. GREIM.

Mr. Greim was General Manager of the Milwaukee Coke and Gas Company which operates by-product coke ovens in Milwaukee, Wis. He had also had a number of years of experience with the coke oven plant at Everett, Mass.

He belonged to the New England, Wisconsin, Ohio, and American Gas Light Associations, and came into the American Gas Institute as a Charter Member.

THOMAS O. HORTON.

At the time of his death Mr. Horton was President and Manager of the New York and Richmond Gas Company of Staten Island, N. Y. Prior to that he had managed the gas companies at Jenkintown, Pa., and Niagara Falls, N. Y., and had also been connected with the East River Gas Company.

Mr. Horton graduated from Yale in 1891. He joined the American Gas Light Association in 1899, and became a Charter Member of the American Gas Institute.

W. A. STADLEMAN.

Mr. Stadleman was Vice-President of the Darley Engineering Company, New York. He joined the American Gas Light Association in 1904, and came into the American Gas Institute as a Charter Member.

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